Author(s): ATLAS Collaboration

Article Title: Measurement of the W^{+}W^{-} cross section in sqrt[s]=7 TeV pp collisions with ATLAS

Year of publication: 2011

Link to published article:
http://dx.doi.org/10.1103/PhysRevLett.107.041802

Measurement of the W^+W^- Cross Section in $\sqrt{s} = 7$ TeV pp Collisions with ATLAS

G. Aad *et al.**
(ATLAS Collaboration)

(Received 27 April 2011; published 20 July 2011)

This Letter presents a measurement of the W^+W^- production cross section in $\sqrt{s} = 7$ TeV pp collisions by the ATLAS experiment, using 34 pb^{-1} of integrated luminosity produced by the Large Hadron Collider at CERN. Selecting events with two isolated leptons, each either an electron or a muon, 8 candidate events are observed with an expected background of 1.7 ± 0.6 events. The measured cross section is $41^{+20}_{-16}(\mathrm{stat}) \pm 5(\mathrm{syst}) \pm 1(\mathrm{lumi})$ pb, which is consistent with the standard model prediction of 44 ± 3 pb calculated at next-to-leading order in QCD.

DOI: 10.1103/PhysRevLett.107.041802 PACS numbers: 14.70.Fm, 12.15.Ji, 13.38.Be, 13.85.Qk

The W^+W^- process plays an important role in electroweak physics. The production rate and kinematic distributions of W^+W^- are sensitive to the triple gauge couplings of the W boson [1,2] and W^+W^- production is an important background to standard model Higgs boson searches. For these reasons, the measurement of the W^+W^- production cross section in 7 TeV pp collisions is a milestone in the Large Hadron Collider (LHC) physics program. W^+W^- production has been previously measured in both e^+e^- collisions [1] and $p\bar{p}$ collisions [2], and was also recently measured in pp collisions [3]. In the standard model, the largest production mechanisms of W^+W^- proceed via s-channel and t-channel quark annihilation [4], followed by the gluon fusion process [5], which is next-to-next-to-leading order but is enhanced by the large gluon-gluon parton luminosity at the LHC.

Candidate W^+W^- events are reconstructed in the leptonic $\ell\ell\nu\nu$ decay channel where each ℓ is either an electron or a muon; included in this selection is W^+W^- production in which either or both W bosons decay to $\tau\nu \rightarrow \ell\nu\nu\nu$. This channel provides a significantly better signal to background ratio than the semileptonic or hadronic channels. Events consistent with $pp \rightarrow W^+W^- + X \rightarrow \ell\ell\nu\nu + X$ are selected by requiring two reconstructed oppositely-charged leptons and a large transverse momentum imbalance due to the neutrinos, which escape detection. There are four main backgrounds, all of comparable size: (i) W + jets production with a jet misidentified as a lepton; (ii) Drell-Yan production, which includes $Z/\gamma^* \rightarrow \ell\ell$ where the observed momentum imbalance is due to mismeasurements and $Z/\gamma^* \rightarrow \tau\tau \rightarrow \ell\ell + 4\nu$; (iii) top production ($t\bar{t}$ and Wt), which also produces two W bosons, but is not considered signal and is suppressed by vetoing candidates with jets; (iv) other diboson processes, which include WZ production decaying to $\ell\ell\ell\nu$ where one charged lepton is lost, ZZ with one Z decaying to charged leptons and one Z decaying to neutrinos, and $W\gamma$ with the photon misidentified as an electron.

The ATLAS detector [6] has a cylindrical geometry [7] and consists of an inner tracking detector surrounded by a 2 T superconducting solenoid, electromagnetic and hadronic calorimeters, and a muon spectrometer with a toroidal magnetic field. The inner detector provides precision tracking for charged particles for $|\eta| < 2.5$. It consists of silicon pixel and strip detectors surrounded by a straw tube tracker that also provides transition radiation measurements for electron identification. The calorimeter system covers the pseudorapidity range $|\eta| < 4.9$. For $|\eta| < 2.5$, the electromagnetic calorimeter is finely segmented and plays an important role in electron identification. The muon spectrometer has separate trigger and high-precision tracking chambers covering $|\eta| < 2.7$. The transverse energy E_T is defined to be $E \sin\theta$, where E is the energy associated with a calorimeter cell or energy cluster. Similarly, p_T is the momentum component transverse to the beam line.

A three-level trigger system selects events to record for offline analysis. During the data-taking period, the selections for at least one electron or muon were made progressively stricter, culminating in an $E_T > 15$ GeV single electron or $p_T > 13$ GeV single muon requirement. The results presented here use a data sample corresponding to 34 pb^{-1} collected during 2010, where the subsystems described were operational.

The signal acceptance is determined from a detailed Monte Carlo simulation. The $q\bar{q} \rightarrow W^+W^-$ signal is simulated up to next-to-leading order in QCD with MC@NLO [8] and the gluon fusion process is simulated with GG2WW [9]; the CTEQ6.6 [10] and CTEQ6M [11] parton distribution functions (PDFs), respectively, are used. HERWIG [12] is used to model W leptonic decays, parton showers, and hadronization, and JIMMY [13] is used to simulate the underlying event. The detector response simulation [14] is based on the GEANT4 program [15]. For the table and

*Full author list given at the end of the article.

figures in this Letter, the standard model expectation for the W^+W^- signal is normalized to 44 ± 3 pb, which is the sum of the quark annihilation (97%) and gluon fusion (3%) processes, as calculated by MC@NLO and GG2WW.

The luminosity in a single bunch-crossing was sufficient to produce multiple collisions, observed as multiple vertices, in the same recorded event. The vertex with the largest sum p_T^2 of the associated tracks is selected as the primary vertex; this selects vertices with a few high p_T tracks over those with many lower p_T tracks. Additional inclusive pp collisions are also simulated to reproduce the vertex multiplicity observed in data.

Electrons are reconstructed from a combination of a track found in the inner detector and an electromagnetic calorimeter energy cluster with $|\eta| < 1.37$ or $1.52 < |\eta| < 2.47$ to avoid the transition region between the barrel and the end-cap electromagnetic calorimeters. Candidate electrons must satisfy the "tight" selection [16], which requires the following measured quantities to be consistent with those from a promptly produced electron: shower shape, ratio of energy deposited in the hadronic to electromagnetic calorimeters, inner-detector track quality, track-to-shower matching, ratio of calorimeter energy measurement to track momentum, and transition radiation in the straw tube tracker. The electron is required to be isolated such that the sum of E_T for calorimeter energy in a cone of size $\Delta R \equiv \sqrt{\Delta\eta^2 + \Delta\phi^2}$ of 0.3 around the electron is less than 6 GeV, excluding energy associated with the electron cluster. The overall electron reconstruction and identification efficiency is measured from data using $W \to e\nu$ and $Z \to ee$ candidates. It varies from 78% for the central region ($|\eta| < 0.8$) to 64% in the forward region ($2.0 < |\eta| < 2.47$) with a statistical uncertainty of less than 0.4% and a systematic uncertainty of 5% [16] averaged over rapidity. The systematic uncertainty is due to background uncertainties in the W and Z samples and the consistency of efficiencies derived from the two samples.

Muon candidates are formed by associating muon spectrometer (MS) tracks with inner detector (ID) tracks after accounting for energy loss in the calorimeter. A common transverse momentum is determined using a statistical combination of the two tracks and is required to have $|\eta| < 2.4$. To reject muons from charged π or K decays and charged particles from the beam-induced backgrounds, the MS muon p_T must exceed 10 GeV and be consistent with the ID measurement, $|p_T^{\rm ID} - p_T^{\rm MS}|/p_T^{\rm ID} < 0.5$. To suppress muons originating from hadronic jets, the sum of the p_T of other tracks with $p_T > 1$ GeV in a cone of $\Delta R = 0.2$ around the muon candidate divided by the muon p_T is required to be less than 0.1. The muon reconstruction and isolation efficiencies are measured in data using $Z \to \mu\mu$ candidates to obtain a combined efficiency of $92 \pm 1(\text{stat}) \pm 1(\text{syst})\%$, where the systematic uncertainty is dominated by variations between data-taking periods due to additional collisions in the events [16].

Jets used to discriminate top from W^+W^- production are reconstructed from calorimeter clusters using the anti-k_T algorithm [17] with a resolution parameter of $R = 0.4$. Jets within a $\Delta R < 0.3$ of an electron are not used because the electrons are in general also reconstructed as jets. The jet energies are calibrated using E_T- and η-dependent correction factors [18] based on simulation and validated by test beam and collision data.

In order to suppress the Drell-Yan background, a momentum imbalance of the visible collision products in the plane transverse to the beam axis is required. For this purpose, missing transverse energy is defined as $\vec{E}_T^{\rm miss} = -\sum \vec{E}_T$, where $\vec{E}_T$ indicate the 2-dimensional transverse vectors for the reconstructed clusters of energy in the calorimeter in the range $|\eta| < 4.5$ and muon momenta. Since the $\vec{E}_T^{\rm miss}$ variable is sensitive to the mismeasurement of an individual lepton or jet, the relative missing transverse energy is defined as

$$E_{T,\rm rel}^{\rm miss} = \begin{cases} E_T^{\rm miss} \times \sin(\Delta\phi) & \text{if } \Delta\phi < /2 \\ E_T^{\rm miss} & \text{if } \Delta\phi \geq /2, \end{cases}$$

where $\Delta\phi$ is the difference in the azimuthal angle ϕ between $\vec{E}_T^{\rm miss}$ and the nearest lepton or jet. This definition allows events to be removed when $\vec{E}_T^{\rm miss}$ points along a lepton direction, which occurs when the lepton momentum is measured lower than the true value or, for events with the two leptons moving in approximately opposite directions, higher than the true value. This generally reduces the contribution from mismeasured leptons giving a higher signal to background ratio than a direct requirement on $|\vec{E}_T^{\rm miss}|$. Two important cases are high-mass muonic Drell-Yan events, where the momentum resolution can be comparable to $|\vec{E}_T^{\rm miss}|$ in W^+W^- events, and $Z \to \tau\tau$, where the real $\vec{E}_T^{\rm miss}$ from leptonic τ decays is parallel to the momenta of the leptons.

Candidates are selected with two opposite-sign charged leptons with $p_T > 20$ GeV. The leptons are required to be consistent with coming from a primary vertex with at least three associated tracks, which makes the cosmic ray background negligible. For the ee and $\mu\mu$ final states, the resulting sample is dominantly $Z \to ee$ and $Z \to \mu\mu$ events, while $e\mu$ candidates are a mix of $Z \to \tau\tau$, $t\bar{t}$, and other backgrounds. In order to suppress $Z/\gamma^* \to ee$ and $Z/\gamma^* \to \mu\mu$, ee and $\mu\mu$ events with an invariant mass near the Z mass, $|m_{\ell\ell} - m_Z| < 10$ GeV, or $m_{\ell\ell} < 15$ GeV are removed and the remainder are required to have $E_{T,\rm rel}^{\rm miss} > 40$ GeV. For $e\mu$ events, a less stringent requirement $E_{T,\rm rel}^{\rm miss} > 20$ GeV is made. In order to suppress the $t\bar{t}$ contribution, candidates containing jets with $p_T > 20$ GeV and $|\eta| < 3$ are removed. Figure 1 shows the $E_{T,\rm rel}^{\rm miss}$ distributions separately for same-flavor (ee and $\mu\mu$) and $e\mu$ events with all selections applied except for the $E_{T,\rm rel}^{\rm miss}$ requirement; also shown is the number of jets with $p_T > 20$ GeV after final selection except for the jet-veto

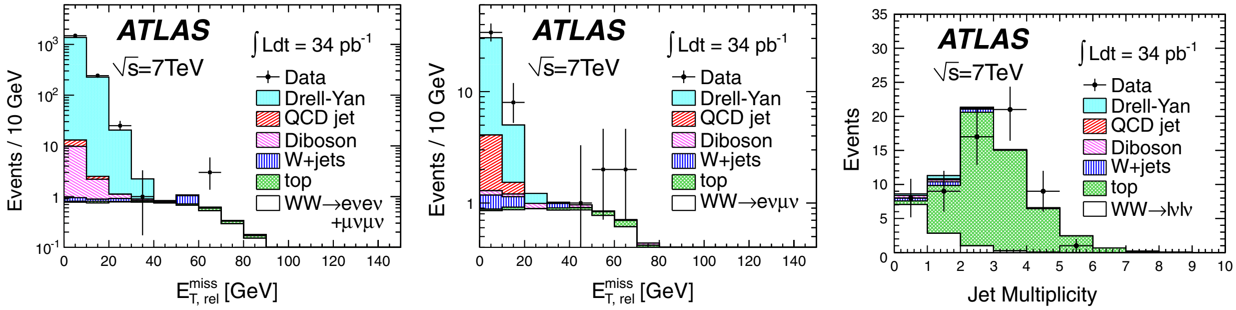

FIG. 1 (color online). $E_{T,\mathrm{rel}}^{\mathrm{miss}}$ distributions for the selected ee and $\mu\mu$ (left) and $e\mu$ (center) events and the multiplicity distribution for jets with $p_{\mathrm{T}} > 20$ GeV and $|\eta| < 3.0$ for all three dilepton channels combined (right). The distributions show events with all selection criteria applied except for $E_{T,\mathrm{rel}}^{\mathrm{miss}}$ in the $E_{T,\mathrm{rel}}^{\mathrm{miss}}$ distribution and the jet-veto in the jet multiplicity distribution. Simulation is used for the QCD jet and W + jets background contributions in these plots as opposed to the data-driven method used for W + jets in the signal region described in the text. The QCD jet contribution is negligible in the signal region.

requirement. In all three distributions, the data in the background regions are in agreement with the standard model expectation and the signal is clearly visible.

The acceptance, which converts the observed yield in the kinematically restricted signal region to the inclusive W^+W^- cross section, is derived from simulation and is corrected with scale factors based on measurements in independent data samples. The scale factors correct for the difference in trigger, lepton reconstruction and identification, and jet-veto efficiencies between data and simulation. The efficiency to pass the trigger criteria is close to unity and has small statistical and systematic uncertainties. For the lepton reconstruction and identification, the scale factors differ from unity by at most a few percent, indicating the accuracy of the simulation, and have systematic uncertainties derived from the efficiency measurements described above. A small smearing is added to the muon p_T in simulation, so that it replicates the $Z \to \mu\mu$ invariant mass distribution in data. The acceptance uncertainty due to the PDF uncertainties is 1.2%.

There are two major sources of systematic uncertainty in the jet-veto efficiency. The first is the modeling of jet production in association with W^+W^- due to initial state radiation, radiation from the internal line in the t-channel diagram, and additional parton collisions in the same pp collision. The second is the jet-energy scale, which is the correspondence between the true particle jet p_T and the reconstructed jet p_T. To minimize the systematic uncertainty due to these two effects, control samples of $Z \to \ell\ell$ are used. These are sufficiently large and pure that the jet-veto efficiency can be directly measured and compared to simulation using the same QCD modeling as the W^+W^- signal. The ratio of the observed to the simulated zero-jet fraction in the $Z \to \ell\ell$ sample to simulation is used to define a jet-veto scale factor of 0.97 ± 0.06. The uncertainty is due to differences between the jet-veto efficiency in Z and W^+W^- events which is assessed including effects from the choice of renormalization and fragmentation scales [19].

The overall selection acceptances for signal events are $4.1 \pm 0.1\%$ for $e\nu e\nu$, $8.6 \pm 0.1\%$ for $\mu\nu\mu\nu$, and $11.5 \pm 0.6\%$ for $e\nu\mu\nu$. The relative acceptance in event selection are lepton acceptance and identification (18%, 41%, 27%) and the m_{ll} (85%, 84%, 100%), $E_{T,\mathrm{rel}}^{\mathrm{miss}}$ (41%, 43%, 69%), and jet-veto (64%, 59%, 61%) requirements, where the three percentages indicate the ee, $\mu\mu$, and $e\mu$ channels, respectively, and each factor is relative to the previous requirement. The contributions from W^+W^- production where one or both W bosons decays to a τ which subsequently decays to an e or μ are less than 10% of the final selected W^+W^- signal events in all three channels.

With the exception of W + jets, the backgrounds are derived from simulations, corrected with the same scale factors as applied to the modeling of the signal acceptance. The backgrounds are scaled to the data sample based on the integrated luminosity and predicted cross sections. The top and WZ processes are simulated with MC@NLO, the ZZ process is simulated with HERWIG, the $W\gamma$ is simulated with madgraph + pythia [20,21], and the Drell-Yan process is simulated with ALPGEN [22] and PYTHIA [20]. The QCD jet contribution, which is not significant after the $E_{T,\mathrm{rel}}^{\mathrm{miss}}$ cut, is modeled with PYTHIA in Fig. 1, which includes data below the $E_{T,\mathrm{rel}}^{\mathrm{miss}}$ requirement.

Like the signal acceptance, the background estimates have uncertainties due to the trigger, lepton reconstruction and identification, and jet-veto efficiencies, in addition to the uncertainties on the integrated luminosity and theoretical cross sections. The Drell-Yan and top background estimates have additional uncertainties described below. Most of the Drell-Yan events are removed by the dilepton invariant mass and $E_{T,\mathrm{rel}}^{\mathrm{miss}}$ requirements, but because of the large cross section some remain as background. The uncertainty on this background due to the simulation of $E_{T,\mathrm{rel}}^{\mathrm{miss}}$ is assessed using a control sample of $Z/\gamma^* \to ee$ and $Z/\gamma^* \to \mu\mu$ events in the Z mass peak region, $|m_{\ell\ell} - m_Z| < 10$ GeV, passing a relaxed requirement of $E_{T,\mathrm{rel}}^{\mathrm{miss}} > 30$ GeV. Despite the $E_{T,\mathrm{rel}}^{\mathrm{miss}}$ requirement, this sample is still dominated by $Z \rightarrow \ell\ell$ events in which the observed momentum imbalance is due to a combination of detector resolution, limited detector coverage, and neutrinos from heavy flavor decays. A 64% systematic uncertainty is assigned based on the difference between the observed yield in data and the Monte Carlo prediction, which are statistically consistent.

The top background arises from $t\bar{t}$ and Wt production where the two W bosons decay leptonically. Simulation based on MC@NLO is used to estimate the number of events passing the jet-veto requirement. Similar to the signal acceptance, there are two important systematic uncertainties on the jet-veto efficiency: the jet-energy scale and the amount of initial and final state radiation (ISR/FSR). The jet-energy calibration uncertainty [18] corresponds to a 40% change in the top background. The uncertainty due to the ISR/FSR modeling is estimated using the ACERMC [23] generator interfaced to PYTHIA [20], and varying the parameters controlling ISR and FSR in a range consistent with experimental data [24]. The resulting uncertainty of 32% is a combination of the shift in the prediction and the statistical uncertainty on the simulation.

W bosons produced in association with a jet that is misidentified as a lepton contribute to the selected sample. The rate at which hadronic jets are misidentified as leptons may not be accurately described in the simulation, because these events are due to rare fragmentation processes or interactions with the detector. This background is therefore determined from data using control samples dominated by W + jets events and subtracting all other components using simulation. The ALPGEN + HERWIG + JIMMY simulation of the W + jets background used in Fig. 1 gives comparable results to this method. The W + jets data samples are constructed by requiring one electron or muon passing the full selection criteria and a leptonlike jet, which is a reconstructed electron or muon that is selected as likely to be due to a jet. For electrons, the leptonlike jets are electromagnetic clusters matched to tracks in the inner detector that fail the full electron selection. For muons, leptonlike jets are muon candidates that fail at least one of the requirements on isolation, distance from the primary vertex, or ID and MS consistency. These events are otherwise required to pass the full event selection, treating the leptonlike jet as if it were a fully identified lepton.

The W + jets background is then estimated by scaling this control sample by a measured p_T-dependent factor f. The factor f is the ratio of the probability for a jet to satisfy the full lepton identification criteria to the probability to satisfy the leptonlike jet criteria. The factor f is measured in a QCD jet data sample and corrected for the small contribution of true leptons to the sample using simulation. The systematic uncertainty on f is 36% for both electrons and muons, and is determined from variations of f in different run periods and in data samples containing jets of different energies, which covers differences in the quark-gluon composition between the jets in the QCD jet and W + jets data samples.

The resulting signal and background expectations are shown in Table I. Eight events are observed in the data with a total expected background of 1.7 ± 0.6 events. As shown in Fig. 2, the kinematic properties of the observed events are qualitatively consistent with the standard model expectation. To estimate the statistical significance of the signal, Poisson-distributed pseudoexperiments are generated, varying the expected background according to its uncertainty. The probability to observe 8 or more events in the absence of a signal is 1.2×10^{-3}, which corresponds to a significance of 3.0 standard deviations. The W^+W^- production cross section is determined using a maximum likelihood fitting method to combine the three dilepton channels. A cross section of $\sigma_{W^+W^-} = 41^{+20}_{-16}(\text{stat}) \pm 5(\text{syst}) \pm 1(\text{lumi})$ pb is measured. The luminosity uncertainty for this measurement is 3.4% [25]. The total systematic uncertainty (11.5%) includes the signal acceptance and efficiency ($\Delta A/A = 7.4\%$) and background estimation ($\Delta N_b/N_b = 33\%$) uncertainties. The dominant systematics uncertainties are due to the jet-veto (7.5%), and the lepton selection and identification (4.3%).

The measured W^+W^- production cross section is in good agreement with the standard model prediction of 44 ± 3 pb calculated at next-to-leading order in QCD and the recent measurement by CMS [3]. With the significantly larger integrated luminosities expected to be

TABLE I. Summary of observed events and expected standard model signal and background contributions in the three dilepton channels and their combination. The first uncertainty is statistical, the second systematic.

Final State	$e^+e^-E_{T,\text{rel}}^{\text{miss}}$	$\mu^+\mu^-E_{T,\text{rel}}^{\text{miss}}$	$e^\pm\mu^\mp E_{T,\text{rel}}^{\text{miss}}$	Combined
Observed Events	1	2	5	8
Expected W^+W^-	$0.79 \pm 0.02 \pm 0.09$	$1.61 \pm 0.04 \pm 0.14$	$4.45 \pm 0.06 \pm 0.44$	$6.85 \pm 0.07 \pm 0.66$
Backgrounds				
Drell-Yan	$0.00 \pm 0.10 \pm 0.07$	$0.01 \pm 0.10 \pm 0.07$	$0.22 \pm 0.06 \pm 0.15$	$0.23 \pm 0.15 \pm 0.17$
WZ, ZZ, $W\gamma$	$0.05 \pm 0.01 \pm 0.01$	$0.10 \pm 0.01 \pm 0.01$	$0.23 \pm 0.05 \pm 0.02$	$0.38 \pm 0.04 \pm 0.04$
W + jets	$0.08 \pm 0.05 \pm 0.03$	$0.00 \pm 0.29 \pm 0.10$	$0.46 \pm 0.12 \pm 0.17$	$0.54 \pm 0.32 \pm 0.21$
Top	$0.04 \pm 0.02 \pm 0.02$	$0.14 \pm 0.06 \pm 0.07$	$0.35 \pm 0.10 \pm 0.19$	$0.53 \pm 0.12 \pm 0.28$
Total Background	$0.17 \pm 0.11 \pm 0.08$	$0.25 \pm 0.31 \pm 0.15$	$1.26 \pm 0.17 \pm 0.31$	$1.68 \pm 0.37 \pm 0.42$

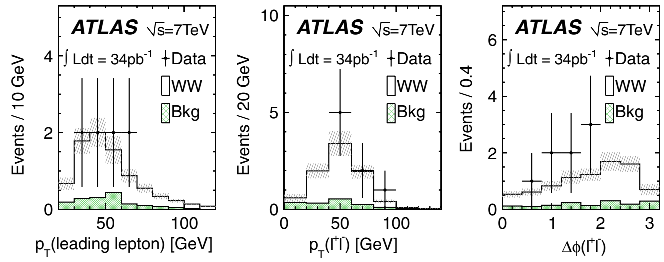

FIG. 2 (color online). Distributions of the leading lepton p_T (left), transverse momentum of the dilepton system (center), and azimuthal angle between the leptons (right) for the sum of the selected ee, $\mu\mu$ and $e\mu$ samples compared to the expectation. The gray band indicates the combined statistical and systematic uncertainty on the sum of the signal and background expectations.

provided by the LHC, this signal will form the basis of a research program that will include searches for the standard model Higgs boson, anomalous triple gauge couplings, and other processes beyond the standard model.

We thank CERN for the very successful operation of the LHC, as well as the support staff from our institutions without whom ATLAS could not be operated efficiently.

We acknowledge the support of ANPCyT, Argentina; YerPhI, Armenia; ARC, Australia; BMWF, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC and CFI, Canada; CERN; CONICYT, Chile; CAS, MOST and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR and VSC CR, Czech Republic; DNRF, DNSRC and Lundbeck Foundation, Denmark; ARTEMIS, European Union; IN2P3-CNRS, CEA-DSM/IRFU, France; GNAS, Georgia; BMBF, DFG, HGF, MPG and AvH Foundation, Germany; GSRT, Greece; ISF, MINERVA, GIF, DIP and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; RCN, Norway; MNiSW, Poland; GRICES and FCT, Portugal; MERYS (MECTS), Romania; MES of Russia and ROSATOM, Russian Federation; JINR; MSTD, Serbia; MSSR, Slovakia; ARRS and MVZT, Slovenia; DST/NRF, South Africa; MICINN, Spain; SRC and Wallenberg Foundation, Sweden; SER, SNSF and Cantons of Bern and Geneva, Switzerland; NSC, Taiwan; TAEK, Turkey; STFC, the Royal Society and Leverhulme Trust, United Kingdom; DOE and NSF, United States of America.

The crucial computing support from all WLCG partners is acknowledged gratefully, in particular, from CERN and the ATLAS Tier-1 facilities at TRIUMF (Canada), NDGF (Denmark, Norway, Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (UK) and BNL (USA) and in the Tier-2 facilities worldwide.

[1] R. Barate *et al.* (ALEPH Collaboration), Phys. Lett. B **484**, 205 (2000); P. Abreu *et al.* (DELPHI Collaboration), Phys. Lett. B **479**, 89 (2000); M. Acciarri *et al.* (L3 Collaboration), Phys. Lett. B **496**, 19 (2000); G. Abbiendi *et al.* (OPAL Collaboration), Phys. Lett. B **493**, 249 (2000).
[2] T. Aaltonen *et al.* (CDF Collaboration), Phys. Rev. Lett. **104**, 201801 (2010); V. M. Abazov*et al.* (D0 Collaboration), Phys. Rev. Lett. **103**, 191801 (2009).
[3] S. Chatrchyan *et al.* (CMS Collaboration), arXiv:1102.5429.
[4] R. W. Brown and K. O. Mikaelian, Phys. Rev. D **19**, 922 (1979).
[5] E. W. N. Glover and J. J. van der Bij, Phys. Lett. B **219**, 488 (1989).
[6] ATLAS Collaboration, JINST **3**, S08003 (2008).
[7] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the center of the detector and the z-axis along the beam pipe. The x-axis points from the IP to the center of the LHC ring, and the y axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the beam pipe. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$.
[8] S. Frixione and B. R. Webber, J. High Energy Phys. 06 (2002) 029.
[9] T. Binoth, M. Ciccolini, N. Kauer, and M. Krämer, J. High Energy Phys. 12 (2006) 046.
[10] P. M. Nadolsky *et al.*, Phys. Rev. D **78**, 013004 (2008).
[11] J. Pumplin *et al.*, J. High Energy Phys. 07 (2002) 012.
[12] G. Corcella *et al.*, J. High Energy Phys. 01 (2001) 010.
[13] J. M. Butterworth *et al.*, Z. Phys. C **72**, 637 (1996).
[14] ATLAS Collaboration, Eur. Phys. J. C **70**, 823 (2010).
[15] S. Agostinelli *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A **506**, 250 (2003).
[16] ATLAS Collaboration, J. High Energy Phys. 12 (2010) 060.
[17] M. Cacciari, G. P. Salam, and G. Soyez, J. High Energy Phys. 04 (2008) 063; M. Cacciari and G. P. Salam, Phys. Lett. B **641**, 57 (2006).
[18] ATLAS Collaboration, Eur. Phys. J. C **71**, 1512 (2011).
[19] J. M. Campbell *et al.*, Phys. Rev. D **80**, 054023 (2009).
[20] T. Sjostrand, S. Mrenna, and P. Skands, J. High Energy Phys. 05 (2006) 026.
[21] J. Alwall *et al.*, J. High Energy Phys. 09 (2007) 028.
[22] M. L. Mangano *et al.*, J. High Energy Phys. 07 (2003) 001.
[23] B. P. Kersevan and E. Richter-Wąs, arXiv:hep-ph/0405247.
[24] P. Z. Skands, Phys. Rev. D **82**, 074018 (2010).
[25] ATLAS Collaboration, Report No. ATLAS-CONF-2011-011, http://cdsweb.cern.ch/record/1334563.

G. Aad,[48] B. Abbott,[111] J. Abdallah,[11] A. A. Abdelalim,[49] A. Abdesselam,[118] O. Abdinov,[10] B. Abi,[112] M. Abolins,[88] H. Abramowicz,[153] H. Abreu,[115] E. Acerbi,[89a,89b] B. S. Acharya,[164a,164b] D. L. Adams,[24] T. N. Addy,[56] J. Adelman,[175] M. Aderholz,[99] S. Adomeit,[98] P. Adragna,[75] T. Adye,[129] S. Aefsky,[22] J. A. Aguilar-Saavedra,[124b,b]

M. Aharrouche,[81] S. P. Ahlen,[21] F. Ahles,[48] A. Ahmad,[148] M. Ahsan,[40] G. Aielli,[133a,133b] T. Akdogan,[18a] T. P. A. Åkesson,[79] G. Akimoto,[155] A. V. Akimov,[94] A. Akiyama,[67] M. S. Alam,[1] M. A. Alam,[76] S. Albrand,[55] M. Aleksa,[29] I. N. Aleksandrov,[65] F. Alessandria,[89a] C. Alexa,[25a] G. Alexander,[153] G. Alexandre,[49] T. Alexopoulos,[9] M. Alhroob,[20] M. Aliev,[15] G. Alimonti,[89a] J. Alison,[120] M. Aliyev,[10] P. P. Allport,[73] S. E. Allwood-Spiers,[53] J. Almond,[82] A. Aloisio,[102a,102b] R. Alon,[171] A. Alonso,[79] M. G. Alviggi,[102a,102b] K. Amako,[66] P. Amaral,[29] C. Amelung,[22] V. V. Ammosov,[128] A. Amorim,[124a,c] G. Amorós,[167] N. Amram,[153] C. Anastopoulos,[139] T. Andeen,[34] C. F. Anders,[20] K. J. Anderson,[30] A. Andreazza,[89a,89b] V. Andrei,[58a] M-L. Andrieux,[55] X. S. Anduaga,[70] A. Angerami,[34] F. Anghinolfi,[29] N. Anjos,[124a] A. Annovi,[47] A. Antonaki,[8] M. Antonelli,[47] S. Antonelli,[19a,19b] A. Antonov,[96] J. Antos,[144b] F. Anulli,[132a] S. Aoun,[83] L. Aperio Bella,[4] R. Apolle,[118] G. Arabidze,[88] I. Aracena,[143] Y. Arai,[66] A. T. H. Arce,[44] J. P. Archambault,[28] S. Arfaoui,[29,d] J-F. Arguin,[14] E. Arik,[18a,a] M. Arik,[18a] A. J. Armbruster,[87] O. Arnaez,[81] C. Arnault,[115] A. Artamonov,[95] G. Artoni,[132a,132b] D. Arutinov,[20] S. Asai,[155] R. Asfandiyarov,[172] S. Ask,[27] B. Åsman,[146a,146b] L. Asquith,[5] K. Assamagan,[24] A. Astbury,[169] A. Astvatsatourov,[52] G. Atoian,[175] B. Aubert,[4] B. Auerbach,[175] E. Auge,[115] K. Augsten,[127] M. Aurousseau,[145a] N. Austin,[73] R. Avramidou,[9] D. Axen,[168] C. Ay,[54] G. Azuelos,[93,e] Y. Azuma,[155] M. A. Baak,[29] G. Baccaglioni,[89a] C. Bacci,[134a,134b] A. M. Bach,[14] H. Bachacou,[136] K. Bachas,[29] G. Bachy,[29] M. Backes,[49] M. Backhaus,[20] E. Badescu,[25a] P. Bagnaia,[132a,132b] S. Bahinipati,[2] Y. Bai,[32a] D. C. Bailey,[158] T. Bain,[158] J. T. Baines,[129] O. K. Baker,[175] M. D. Baker,[24] S. Baker,[77] F. Baltasar Dos Santos Pedrosa,[29] E. Banas,[38] P. Banerjee,[93] Sw. Banerjee,[169] D. Banfi,[29] A. Bangert,[137] V. Bansal,[169] H. S. Bansil,[17] L. Barak,[171] S. P. Baranov,[94] A. Barashkou,[65] A. Barbaro Galtieri,[14] T. Barber,[27] E. L. Barberio,[86] D. Barberis,[50a,50b] M. Barbero,[20] D. Y. Bardin,[65] T. Barillari,[99] M. Barisonzi,[174] T. Barklow,[143] N. Barlow,[27] B. M. Barnett,[129] R. M. Barnett,[14] A. Baroncelli,[134a] A. J. Barr,[118] F. Barreiro,[80] J. Barreiro Guimarães da Costa,[57] P. Barrillon,[115] R. Bartoldus,[143] A. E. Barton,[71] D. Bartsch,[20] V. Bartsch,[149] R. L. Bates,[53] L. Batkova,[144a] J. R. Batley,[27] A. Battaglia,[16] M. Battistin,[29] G. Battistoni,[89a] F. Bauer,[136] H. S. Bawa,[143,f] B. Beare,[158] T. Beau,[78] P. H. Beauchemin,[118] R. Beccherle,[50a] P. Bechtle,[41] H. P. Beck,[16] M. Beckingham,[48] K. H. Becks,[174] A. J. Beddall,[18c] A. Beddall,[18c] S. Bedikian,[175] V. A. Bednyakov,[65] C. P. Bee,[83] M. Begel,[24] S. Behar Harpaz,[152] P. K. Behera,[63] M. Beimforde,[99] C. Belanger-Champagne,[166] P. J. Bell,[49] W. H. Bell,[49] G. Bella,[153] L. Bellagamba,[19a] F. Bellina,[29] M. Bellomo,[119a] A. Belloni,[57] O. Beloborodova,[107] K. Belotskiy,[96] O. Beltramello,[29] S. Ben Ami,[152] O. Benary,[153] D. Benchekroun,[135a] C. Benchouk,[83] M. Bendel,[81] B. H. Benedict,[163] N. Benekos,[165] Y. Benhammou,[153] D. P. Benjamin,[44] M. Benoit,[115] J. R. Bensinger,[22] K. Benslama,[130] S. Bentvelsen,[105] D. Berge,[29] E. Bergeaas Kuutmann,[41] N. Berger,[4] F. Berghaus,[169] E. Berglund,[49] J. Beringer,[14] K. Bernardet,[83] P. Bernat,[77] R. Bernhard,[48] C. Bernius,[24] T. Berry,[76] A. Bertin,[19a,19b] F. Bertinelli,[29] F. Bertolucci,[122a,122b] M. I. Besana,[89a,89b] N. Besson,[136] S. Bethke,[99] W. Bhimji,[45] R. M. Bianchi,[29] M. Bianco,[72a,72b] O. Biebel,[98] S. P. Bieniek,[77] J. Biesiada,[14] M. Biglietti,[134a,134b] H. Bilokon,[47] M. Bindi,[19a,19b] S. Binet,[115] A. Bingul,[18c] C. Bini,[132a,132b] C. Biscarat,[177] U. Bitenc,[48] K. M. Black,[21] R. E. Blair,[5] J.-B. Blanchard,[115] G. Blanchot,[29] T. Blazek,[144a] C. Blocker,[22] J. Blocki,[38] A. Blondel,[49] W. Blum,[81] U. Blumenschein,[54] G. J. Bobbink,[105] V. B. Bobrovnikov,[107] S. S. Bocchetta,[79] A. Bocci,[44] C. R. Boddy,[118] M. Boehler,[41] J. Boek,[174] N. Boelaert,[35] S. Böser,[77] J. A. Bogaerts,[29] A. Bogdanchikov,[107] A. Bogouch,[90,a] C. Bohm,[146a] V. Boisvert,[76] T. Bold,[163,g] V. Boldea,[25a] N. M. Bolnet,[136] M. Bona,[75] V. G. Bondarenko,[96] M. Boonekamp,[136] G. Boorman,[76] C. N. Booth,[139] S. Bordoni,[78] C. Borer,[16] A. Borisov,[128] G. Borissov,[71] I. Borjanovic,[12a] S. Borroni,[132a,132b] K. Bos,[105] D. Boscherini,[19a] M. Bosman,[11] H. Boterenbrood,[105] D. Botterill,[129] J. Bouchami,[93] J. Boudreau,[123] E. V. Bouhova-Thacker,[71] C. Boulahouache,[123] C. Bourdarios,[115] N. Bousson,[83] A. Boveia,[30] J. Boyd,[29] I. R. Boyko,[65] N. I. Bozhko,[128] I. Bozovic-Jelisavcic,[12b] J. Bracinik,[17] A. Braem,[29] P. Branchini,[134a] G. W. Brandenburg,[57] A. Brandt,[7] G. Brandt,[15] O. Brandt,[54] U. Bratzler,[156] B. Brau,[84] J. E. Brau,[114] H. M. Braun,[174] B. Brelier,[158] J. Bremer,[29] R. Brenner,[166] S. Bressler,[152] D. Breton,[115] D. Britton,[53] F. M. Brochu,[27] I. Brock,[20] R. Brock,[88] T. J. Brodbeck,[71] E. Brodet,[153] F. Broggi,[89a] C. Bromberg,[88] G. Brooijmans,[34] W. K. Brooks,[31b] G. Brown,[82] H. Brown,[7] E. Brubaker,[30] P. A. Bruckman de Renstrom,[38] D. Bruncko,[144b] R. Bruneliere,[48] S. Brunet,[61] A. Bruni,[19a] G. Bruni,[19a] M. Bruschi,[19a] T. Buanes,[13] F. Bucci,[49] J. Buchanan,[118] N. J. Buchanan,[2] P. Buchholz,[141] R. M. Buckingham,[118] A. G. Buckley,[45] S. I. Buda,[25a] I. A. Budagov,[65] B. Budick,[108] V. Büscher,[81] L. Bugge,[117] D. Buira-Clark,[118] O. Bulekov,[96] M. Bunse,[42] T. Buran,[117] H. Burckhart,[29] S. Burdin,[73] T. Burgess,[13] S. Burke,[129] E. Busato,[33] P. Bussey,[53] C. P. Buszello,[166] F. Butin,[29] B. Butler,[143] J. M. Butler,[21] C. M. Buttar,[53] J. M. Butterworth,[77] W. Buttinger,[27] T. Byatt,[77] S. Cabrera Urbán,[167] D. Caforio,[19a,19b] O. Cakir,[3a] P. Calafiura,[14] G. Calderini,[78] P. Calfayan,[98] R. Calkins,[106] L. P. Caloba,[23a] R. Caloi,[132a,132b] D. Calvet,[33] S. Calvet,[33]

R. Camacho Toro,[33] A. Camard,[78] P. Camarri,[133a,133b] M. Cambiaghi,[119a,119b] D. Cameron,[117] J. Cammin,[20] S. Campana,[29] M. Campanelli,[77] V. Canale,[102a,102b] F. Canelli,[30] A. Canepa,[159a] J. Cantero,[80] L. Capasso,[102a,102b] M. D. M. Capeans Garrido,[29] I. Caprini,[25a] M. Caprini,[25a] D. Capriotti,[99] M. Capua,[36a,36b] R. Caputo,[148] C. Caramarcu,[25a] R. Cardarelli,[133a] T. Carli,[29] G. Carlino,[102a] L. Carminati,[89a,89b] B. Caron,[159a] S. Caron,[48] G. D. Carrillo Montoya,[172] A. A. Carter,[75] J. R. Carter,[27] J. Carvalho,[124a,h] D. Casadei,[108] M. P. Casado,[11] M. Cascella,[122a,122b] C. Caso,[50a,50b,a] A. M. Castaneda Hernandez,[172] E. Castaneda-Miranda,[172] V. Castillo Gimenez,[167] N. F. Castro,[124a] G. Cataldi,[72a] F. Cataneo,[29] A. Catinaccio,[29] J. R. Catmore,[71] A. Cattai,[29] G. Cattani,[133a,133b] S. Caughron,[88] D. Cauz,[164a,164c] P. Cavalleri,[78] D. Cavalli,[89a] M. Cavalli-Sforza,[11] V. Cavasinni,[122a,122b] A. Cazzato,[72a,72b] F. Ceradini,[134a,134b] A. S. Cerqueira,[23a] A. Cerri,[29] L. Cerrito,[75] F. Cerutti,[47] S. A. Cetin,[18b] F. Cevenini,[102a,102b] A. Chafaq,[135a] D. Chakraborty,[106] K. Chan,[2] B. Chapleau,[85] J. D. Chapman,[27] J. W. Chapman,[87] E. Chareyre,[78] D. G. Charlton,[17] V. Chavda,[82] S. Cheatham,[71] S. Chekanov,[5] S. V. Chekulaev,[159a] G. A. Chelkov,[65] M. A. Chelstowska,[104] C. Chen,[64] H. Chen,[24] L. Chen,[2] S. Chen,[32c] T. Chen,[32c] X. Chen,[172] S. Cheng,[32a] A. Cheplakov,[65] V. F. Chepurnov,[65] R. Cherkaoui El Moursli,[135e] V. Chernyatin,[24] E. Cheu,[6] S. L. Cheung,[158] L. Chevalier,[136] G. Chiefari,[102a,102b] L. Chikovani,[51] J. T. Childers,[58a] A. Chilingarov,[71] G. Chiodini,[72a] M. V. Chizhov,[65] G. Choudalakis,[30] S. Chouridou,[137] I. A. Christidi,[77] A. Christov,[48] D. Chromek-Burckhart,[29] M. L. Chu,[151] J. Chudoba,[125] G. Ciapetti,[132a,132b] K. Ciba,[37] A. K. Ciftci,[3a] R. Ciftci,[3a] D. Cinca,[33] V. Cindro,[74] M. D. Ciobotaru,[163] C. Ciocca,[19a,19b] A. Ciocio,[14] M. Cirilli,[87] M. Ciubancan,[25a] A. Clark,[49] P. J. Clark,[45] W. Cleland,[123] J. C. Clemens,[83] B. Clement,[55] C. Clement,[146a,146b] R. W. Clifft,[129] Y. Coadou,[83] M. Cobal,[164a,164c] A. Coccaro,[50a,50b] J. Cochran,[64] P. Coe,[118] J. G. Cogan,[143] J. Coggeshall,[165] E. Cogneras,[177] C. D. Cojocaru,[28] J. Colas,[4] A. P. Colijn,[105] C. Collard,[115] N. J. Collins,[17] C. Collins-Tooth,[53] J. Collot,[55] G. Colon,[84] P. Conde Muiño,[124a] E. Coniavitis,[118] M. C. Conidi,[11] M. Consonni,[104] S. Constantinescu,[25a] C. Conta,[119a,119b] F. Conventi,[102a,i] J. Cook,[29] M. Cooke,[14] B. D. Cooper,[77] A. M. Cooper-Sarkar,[118] N. J. Cooper-Smith,[76] K. Copic,[34] T. Cornelissen,[50a,50b] M. Corradi,[19a] F. Corriveau,[85,j] A. Cortes-Gonzalez,[165] G. Cortiana,[99] G. Costa,[89a] M. J. Costa,[167] D. Costanzo,[139] T. Costin,[30] D. Côté,[29] R. Coura Torres,[23a] L. Courneyea,[169] G. Cowan,[76] C. Cowden,[27] B. E. Cox,[82] K. Cranmer,[108] F. Crescioli,[122a,122b] M. Cristinziani,[20] G. Crosetti,[36a,36b] R. Crupi,[72a,72b] S. Crépé-Renaudin,[55] C.-M. Cuciuc,[25a] C. Cuenca Almenar,[175] T. Cuhadar Donszelmann,[139] S. Cuneo,[50a,50b] M. Curatolo,[47] C. J. Curtis,[17] P. Cwetanski,[61] H. Czirr,[141] Z. Czyczula,[117] S. D'Auria,[53] M. D'Onofrio,[73] A. D'Orazio,[132a,132b] A. Da Rocha Gesualdi Mello,[23a] P. V. M. Da Silva,[23a] C. Da Via,[82] W. Dabrowski,[37] A. Dahlhoff,[48] T. Dai,[87] C. Dallapiccola,[84] M. Dam,[35] M. Dameri,[50a,50b] D. S. Damiani,[137] H. O. Danielsson,[29] D. Dannheim,[99] V. Dao,[49] G. Darbo,[50a] G. L. Darlea,[25b] C. Daum,[105] J. P. Dauvergne,[29] W. Davey,[86] T. Davidek,[126] N. Davidson,[86] R. Davidson,[71] M. Davies,[93] A. R. Davison,[77] E. Dawe,[142] I. Dawson,[139] J. W. Dawson,[5,a] R. K. Daya,[39] K. De,[7] R. de Asmundis,[102a] S. De Castro,[19a,19b] P. E. De Castro Faria Salgado,[24] S. De Cecco,[78] J. de Graat,[98] N. De Groot,[104] P. de Jong,[105] C. De La Taille,[115] H. De la Torre,[80] B. De Lotto,[164a,164c] L. De Mora,[71] L. De Nooij,[105] M. De Oliveira Branco,[29] D. De Pedis,[132a] P. de Saintignon,[55] A. De Salvo,[132a] U. De Sanctis,[164a,164c] A. De Santo,[149] J. B. De Vivie De Regie,[115] S. Dean,[77] D. V. Dedovich,[65] J. Degenhardt,[120] M. Dehchar,[118] M. Deile,[98] C. Del Papa,[164a,164c] J. Del Peso,[80] T. Del Prete,[122a,122b] A. Dell'Acqua,[29] L. Dell'Asta,[89a,89b] M. Della Pietra,[102a,i] D. della Volpe,[102a,102b] M. Delmastro,[29] P. Delpierre,[83] N. Delruelle,[29] P. A. Delsart,[55] C. Deluca,[148] S. Demers,[175] M. Demichev,[65] B. Demirkoz,[11,k] J. Deng,[163] S. P. Denisov,[128] D. Derendarz,[38] J. E. Derkaoui,[135d] F. Derue,[78] P. Dervan,[73] K. Desch,[20] E. Devetak,[148] P. O. Deviveiros,[158] A. Dewhurst,[129] B. DeWilde,[148] S. Dhaliwal,[158] R. Dhullipudi,[24,l] A. Di Ciaccio,[133a,133b] L. Di Ciaccio,[4] A. Di Girolamo,[29] B. Di Girolamo,[29] S. Di Luise,[134a,134b] A. Di Mattia,[88] B. Di Micco,[29] R. Di Nardo,[133a,133b] A. Di Simone,[133a,133b] R. Di Sipio,[19a,19b] M. A. Diaz,[31a] F. Diblen,[18c] E. B. Diehl,[87] H. Dietl,[99] J. Dietrich,[48] T. A. Dietzsch,[58a] S. Diglio,[115] K. Dindar Yagci,[39] J. Dingfelder,[20] C. Dionisi,[132a,132b] P. Dita,[25a] S. Dita,[25a] F. Dittus,[29] F. Djama,[83] R. Djilkibaev,[108] T. Djobava,[51] M. A. B. do Vale,[23a] A. Do Valle Wemans,[124a] T. K. O. Doan,[4] M. Dobbs,[85] R. Dobinson,[29,a] D. Dobos,[42] E. Dobson,[29] M. Dobson,[163] J. Dodd,[34] O. B. Dogan,[18a,a] C. Doglioni,[118] T. Doherty,[53] Y. Doi,[66,a] J. Dolejsi,[126] I. Dolenc,[74] Z. Dolezal,[126] B. A. Dolgoshein,[96,a] T. Dohmae,[155] M. Donadelli,[23b] M. Donega,[120] J. Donini,[55] J. Dopke,[29] A. Doria,[102a] A. Dos Anjos,[172] M. Dosil,[11] A. Dotti,[122a,122b] M. T. Dova,[70] J. D. Dowell,[17] A. D. Doxiadis,[105] A. T. Doyle,[53] Z. Drasal,[126] J. Drees,[174] N. Dressnandt,[120] H. Drevermann,[29] C. Driouichi,[35] M. Dris,[9] J. Dubbert,[99] T. Dubbs,[137] S. Dube,[14] E. Duchovni,[171] G. Duckeck,[98] A. Dudarev,[29] F. Dudziak,[64] M. Dührssen,[29] I. P. Duerdoth,[82] L. Duflot,[115] M-A. Dufour,[85] M. Dunford,[29] H. Duran Yildiz,[3b] R. Duxfield,[139] M. Dwuznik,[37] F. Dydak,[29] D. Dzahini,[55] M. Düren,[52] W. L. Ebenstein,[44] J. Ebke,[98] S. Eckert,[48] S. Eckweiler,[81]

K. Edmonds,[81] C. A. Edwards,[76] W. Ehrenfeld,[41] T. Ehrich,[99] T. Eifert,[29] G. Eigen,[13] K. Einsweiler,[14] E. Eisenhandler,[75] T. Ekelof,[166] M. El Kacimi,[135c] M. Ellert,[166] S. Elles,[4] F. Ellinghaus,[81] K. Ellis,[75] N. Ellis,[29] J. Elmsheuser,[98] M. Elsing,[29] R. Ely,[14] D. Emeliyanov,[129] R. Engelmann,[148] A. Engl,[98] B. Epp,[62] A. Eppig,[87] J. Erdmann,[54] A. Ereditato,[16] D. Eriksson,[146a] J. Ernst,[1] M. Ernst,[24] J. Ernwein,[136] D. Errede,[165] S. Errede,[165] E. Ertel,[81] M. Escalier,[115] C. Escobar,[167] X. Espinal Curull,[11] B. Esposito,[47] F. Etienne,[83] A. I. Etienvre,[136] E. Etzion,[153] D. Evangelakou,[54] H. Evans,[61] L. Fabbri,[19a,19b] C. Fabre,[29] R. M. Fakhrutdinov,[128] S. Falciano,[132a] A. C. Falou,[115] Y. Fang,[172] M. Fanti,[89a,89b] A. Farbin,[7] A. Farilla,[134a] J. Farley,[148] T. Farooque,[158] S. M. Farrington,[118] P. Farthouat,[29] P. Fassnacht,[29] D. Fassouliotis,[8] B. Fatholahzadeh,[158] A. Favareto,[89a,89b] L. Fayard,[115] S. Fazio,[36a,36b] R. Febbraro,[33] P. Federic,[144a] O. L. Fedin,[121] I. Fedorko,[29] W. Fedorko,[88] M. Fehling-Kaschek,[48] L. Feligioni,[83] D. Fellmann,[5] C. U. Felzmann,[86] C. Feng,[32d] E. J. Feng,[30] A. B. Fenyuk,[128] J. Ferencei,[144b] J. Ferland,[93] W. Fernando,[109] S. Ferrag,[53] J. Ferrando,[53] V. Ferrara,[41] A. Ferrari,[166] P. Ferrari,[105] R. Ferrari,[119a] A. Ferrer,[167] M. L. Ferrer,[47] D. Ferrere,[49] C. Ferretti,[87] A. Ferretto Parodi,[50a,50b] M. Fiascaris,[30] F. Fiedler,[81] A. Filipčič,[74] A. Filippas,[9] F. Filthaut,[104] M. Fincke-Keeler,[169] M. C. N. Fiolhais,[124a,h] L. Fiorini,[11] A. Firan,[39] G. Fischer,[41] P. Fischer,[20] M. J. Fisher,[109] S. M. Fisher,[129] M. Flechl,[48] I. Fleck,[141] J. Fleckner,[81] P. Fleischmann,[173] S. Fleischmann,[174] T. Flick,[174] L. R. Flores Castillo,[172] M. J. Flowerdew,[99] F. Föhlisch,[58a] M. Fokitis,[9] T. Fonseca Martin,[16] D. A. Forbush,[138] A. Formica,[136] A. Forti,[82] D. Fortin,[159a] J. M. Foster,[82] D. Fournier,[115] A. Foussat,[29] A. J. Fowler,[44] K. Fowler,[137] H. Fox,[71] P. Francavilla,[122a,122b] S. Franchino,[119a,119b] D. Francis,[29] T. Frank,[171] M. Franklin,[57] S. Franz,[29] M. Fraternali,[119a,119b] S. Fratina,[120] S. T. French,[27] R. Froeschl,[29] D. Froidevaux,[29] J. A. Frost,[27] C. Fukunaga,[156] E. Fullana Torregrosa,[29] J. Fuster,[167] C. Gabaldon,[29] O. Gabizon,[171] T. Gadfort,[24] S. Gadomski,[49] G. Gagliardi,[50a,50b] P. Gagnon,[61] C. Galea,[98] E. J. Gallas,[118] M. V. Gallas,[29] V. Gallo,[16] B. J. Gallop,[129] P. Gallus,[125] E. Galyaev,[40] K. K. Gan,[109] Y. S. Gao,[143,f] V. A. Gapienko,[128] A. Gaponenko,[14] F. Garberson,[175] M. Garcia-Sciveres,[14] C. García,[167] J. E. García Navarro,[49] R. W. Gardner,[30] N. Garelli,[29] H. Garitaonandia,[105] V. Garonne,[29] J. Garvey,[17] C. Gatti,[47] G. Gaudio,[119a] O. Gaumer,[49] B. Gaur,[141] L. Gauthier,[136] I. L. Gavrilenko,[94] C. Gay,[168] G. Gaycken,[20] J-C. Gayde,[29] E. N. Gazis,[9] P. Ge,[32d] C. N. P. Gee,[129] D. A. A. Geerts,[105] Ch. Geich-Gimbel,[20] K. Gellerstedt,[146a,146b] C. Gemme,[50a] A. Gemmell,[53] M. H. Genest,[98] S. Gentile,[132a,132b] M. George,[54] S. George,[76] P. Gerlach,[174] A. Gershon,[153] C. Geweniger,[58a] H. Ghazlane,[135b] P. Ghez,[4] N. Ghodbane,[33] B. Giacobbe,[19a] S. Giagu,[132a,132b] V. Giakoumopoulou,[8] V. Giangiobbe,[122a,122b] F. Gianotti,[29] B. Gibbard,[24] A. Gibson,[158] S. M. Gibson,[29] L. M. Gilbert,[118] M. Gilchriese,[14] V. Gilewsky,[91] D. Gillberg,[28] A. R. Gillman,[129] D. M. Gingrich,[2,e] J. Ginzburg,[153] N. Giokaris,[8] R. Giordano,[102a,102b] F. M. Giorgi,[15] P. Giovannini,[99] P. F. Giraud,[136] D. Giugni,[89a] M. Giunta,[132a,132b] P. Giusti,[19a] B. K. Gjelsten,[117] L. K. Gladilin,[97] C. Glasman,[80] J. Glatzer,[48] A. Glazov,[41] K. W. Glitza,[174] G. L. Glonti,[65] J. Godfrey,[142] J. Godlewski,[29] M. Goebel,[41] T. Göpfert,[43] C. Goeringer,[81] C. Gössling,[42] T. Göttfert,[99] S. Goldfarb,[87] D. Goldin,[39] T. Golling,[175] S. N. Golovnia,[128] A. Gomes,[124a,c] L. S. Gomez Fajardo,[41] R. Gonçalo,[76] J. Goncalves Pinto Firmino Da Costa,[41] L. Gonella,[20] A. Gonidec,[29] S. Gonzalez,[172] S. González de la Hoz,[167] M. L. Gonzalez Silva,[26] S. Gonzalez-Sevilla,[49] J. J. Goodson,[148] L. Goossens,[29] P. A. Gorbounov,[95] H. A. Gordon,[24] I. Gorelov,[103] G. Gorfine,[174] B. Gorini,[29] E. Gorini,[72a,72b] A. Gorišek,[74] E. Gornicki,[38] S. A. Gorokhov,[128] V. N. Goryachev,[128] B. Gosdzik,[41] M. Gosselink,[105] M. I. Gostkin,[65] M. Gouanère,[4] I. Gough Eschrich,[163] M. Gouighri,[135a] D. Goujdami,[135c] M. P. Goulette,[49] A. G. Goussiou,[138] C. Goy,[4] I. Grabowska-Bold,[163,g] V. Grabski,[176] P. Grafström,[29] C. Grah,[174] K-J. Grahn,[147] F. Grancagnolo,[72a] S. Grancagnolo,[15] V. Grassi,[148] V. Gratchev,[121] N. Grau,[34] H. M. Gray,[29] J. A. Gray,[148] E. Graziani,[134a] O. G. Grebenyuk,[121] D. Greenfield,[129] T. Greenshaw,[73] Z. D. Greenwood,[24,l] I. M. Gregor,[41] P. Grenier,[143] E. Griesmayer,[46] J. Griffiths,[138] N. Grigalashvili,[65] A. A. Grillo,[137] S. Grinstein,[11] Ph. Gris,[33] Y. V. Grishkevich,[97] J.-F. Grivaz,[115] J. Grognuz,[29] M. Groh,[99] E. Gross,[171] J. Grosse-Knetter,[54] J. Groth-Jensen,[79] K. Grybel,[141] V. J. Guarino,[5] D. Guest,[175] C. Guicheney,[33] A. Guida,[72a,72b] T. Guillemin,[4] S. Guindon,[54] H. Guler,[85,m] J. Gunther,[125] B. Guo,[158] J. Guo,[34] A. Gupta,[30] Y. Gusakov,[65] V. N. Gushchin,[128] A. Gutierrez,[93] P. Gutierrez,[111] N. Guttman,[153] O. Gutzwiller,[172] C. Guyot,[136] C. Gwenlan,[118] C. B. Gwilliam,[73] A. Haas,[143] S. Haas,[29] C. Haber,[14] R. Hackenburg,[24] H. K. Hadavand,[39] D. R. Hadley,[17] P. Haefner,[99] F. Hahn,[29] S. Haider,[29] Z. Hajduk,[38] H. Hakobyan,[176] J. Haller,[54] K. Hamacher,[174] P. Hamal,[113] A. Hamilton,[49] S. Hamilton,[161] H. Han,[32a] L. Han,[32b] K. Hanagaki,[116] M. Hance,[120] C. Handel,[81] P. Hanke,[58a] J. R. Hansen,[35] J. B. Hansen,[35] J. D. Hansen,[35] P. H. Hansen,[35] P. Hansson,[143] K. Hara,[160] G. A. Hare,[137] T. Harenberg,[174] S. Harkusha,[90] D. Harper,[87] R. D. Harrington,[21] O. M. Harris,[138] K. Harrison,[17] J. Hartert,[48] F. Hartjes,[105] T. Haruyama,[66] A. Harvey,[56] S. Hasegawa,[101] Y. Hasegawa,[140] S. Hassani,[136] M. Hatch,[29] D. Hauff,[99] S. Haug,[16] M. Hauschild,[29] R. Hauser,[88]

M. Havranek,[20] B. M. Hawes,[118] C. M. Hawkes,[17] R. J. Hawkings,[29] D. Hawkins,[163] T. Hayakawa,[67] D. Hayden,[76] H. S. Hayward,[73] S. J. Haywood,[129] E. Hazen,[21] M. He,[32d] S. J. Head,[17] V. Hedberg,[79] L. Heelan,[7] S. Heim,[88] B. Heinemann,[14] S. Heisterkamp,[35] L. Helary,[4] M. Heldmann,[48] M. Heller,[115] S. Hellman,[146a,146b] C. Helsens,[11] R. C. W. Henderson,[71] M. Henke,[58a] A. Henrichs,[54] A. M. Henriques Correia,[29] S. Henrot-Versille,[115] F. Henry-Couannier,[83] C. Hensel,[54] T. Henß,[174] C. M. Hernandez,[7] Y. Hernández Jiménez,[167] R. Herrberg,[15] A. D. Hershenhorn,[152] G. Herten,[48] R. Hertenberger,[98] L. Hervas,[29] N. P. Hessey,[105] A. Hidvegi,[146a] E. Higón-Rodriguez,[167] D. Hill,[5,a] J. C. Hill,[27] N. Hill,[5] K. H. Hiller,[41] S. Hillert,[20] S. J. Hillier,[17] I. Hinchliffe,[14] E. Hines,[120] M. Hirose,[116] F. Hirsch,[42] D. Hirschbuehl,[174] J. Hobbs,[148] N. Hod,[153] M. C. Hodgkinson,[139] P. Hodgson,[139] A. Hoecker,[29] M. R. Hoeferkamp,[103] J. Hoffman,[39] D. Hoffmann,[83] M. Hohlfeld,[81] M. Holder,[141] A. Holmes,[118] S. O. Holmgren,[146a] T. Holy,[127] J. L. Holzbauer,[88] Y. Homma,[67] T. M. Hong,[120] L. Hooft van Huysduynen,[108] T. Horazdovsky,[127] C. Horn,[143] S. Horner,[48] K. Horton,[118] J-Y. Hostachy,[55] S. Hou,[151] M. A. Houlden,[73] A. Hoummada,[135a] J. Howarth,[82] D. F. Howell,[118] I. Hristova,[41] J. Hrivnac,[115] I. Hruska,[125] T. Hryn'ova,[4] P. J. Hsu,[175] S.-C. Hsu,[14] G. S. Huang,[111] Z. Hubacek,[127] F. Hubaut,[83] F. Huegging,[20] T. B. Huffman,[118] E. W. Hughes,[34] G. Hughes,[71] R. E. Hughes-Jones,[82] M. Huhtinen,[29] P. Hurst,[57] M. Hurwitz,[14] U. Husemann,[41] N. Huseynov,[65,n] J. Huston,[88] J. Huth,[57] G. Iacobucci,[102a] G. Iakovidis,[9] M. Ibbotson,[82] I. Ibragimov,[141] R. Ichimiya,[67] L. Iconomidou-Fayard,[115] J. Idarraga,[115] M. Idzik,[37] P. Iengo,[102a,102b] O. Igonkina,[105] Y. Ikegami,[66] M. Ikeno,[66] Y. Ilchenko,[39] D. Iliadis,[154] D. Imbault,[78] M. Imhaeuser,[174] M. Imori,[155] T. Ince,[20] J. Inigo-Golfin,[29] P. Ioannou,[8] M. Iodice,[134a] G. Ionescu,[4] A. Irles Quiles,[167] K. Ishii,[66] A. Ishikawa,[67] M. Ishino,[66] R. Ishmukhametov,[39] C. Issever,[118] S. Istin,[18a] Y. Itoh,[101] A. V. Ivashin,[128] W. Iwanski,[38] H. Iwasaki,[66] J. M. Izen,[40] V. Izzo,[102a] B. Jackson,[120] J. N. Jackson,[73] P. Jackson,[143] M. R. Jaekel,[29] V. Jain,[61] K. Jakobs,[48] S. Jakobsen,[35] J. Jakubek,[127] D. K. Jana,[111] E. Jankowski,[158] E. Jansen,[77] A. Jantsch,[99] M. Janus,[20] G. Jarlskog,[79] L. Jeanty,[57] K. Jelen,[37] I. Jen-La Plante,[30] P. Jenni,[29] A. Jeremie,[4] P. Jež,[35] S. Jézéquel,[4] M. K. Jha,[19a] H. Ji,[172] W. Ji,[81] J. Jia,[148] Y. Jiang,[32b] M. Jimenez Belenguer,[41] G. Jin,[32b] S. Jin,[32a] O. Jinnouchi,[157] M. D. Joergensen,[35] D. Joffe,[39] L. G. Johansen,[13] M. Johansen,[146a,146b] K. E. Johansson,[146a] P. Johansson,[139] S. Johnert,[41] K. A. Johns,[6] K. Jon-And,[146a,146b] G. Jones,[82] R. W. L. Jones,[71] T. W. Jones,[77] T. J. Jones,[73] O. Jonsson,[29] C. Joram,[29] P. M. Jorge,[124a,c] J. Joseph,[14] X. Ju,[130] V. Juranek,[125] P. Jussel,[62] V. V. Kabachenko,[128] S. Kabana,[16] M. Kaci,[167] A. Kaczmarska,[38] P. Kadlecik,[35] M. Kado,[115] H. Kagan,[109] M. Kagan,[57] S. Kaiser,[99] E. Kajomovitz,[152] S. Kalinin,[174] L. V. Kalinovskaya,[65] S. Kama,[39] N. Kanaya,[155] M. Kaneda,[155] T. Kanno,[157] V. A. Kantserov,[96] J. Kanzaki,[66] B. Kaplan,[175] A. Kapliy,[30] J. Kaplon,[29] D. Kar,[43] M. Karagoz,[118] M. Karnevskiy,[41] K. Karr,[5] V. Kartvelishvili,[71] A. N. Karyukhin,[128] L. Kashif,[172] A. Kasmi,[39] R. D. Kass,[109] A. Kastanas,[13] M. Kataoka,[4] Y. Kataoka,[155] E. Katsoufis,[9] J. Katzy,[41] V. Kaushik,[6] K. Kawagoe,[67] T. Kawamoto,[155] G. Kawamura,[81] M. S. Kayl,[105] V. A. Kazanin,[107] M. Y. Kazarinov,[65] J. R. Keates,[82] R. Keeler,[169] R. Kehoe,[39] M. Keil,[54] G. D. Kekelidze,[65] M. Kelly,[82] J. Kennedy,[98] C. J. Kenney,[143] M. Kenyon,[53] O. Kepka,[125] N. Kerschen,[29] B. P. Kerševan,[74] S. Kersten,[174] K. Kessoku,[155] C. Ketterer,[48] J. Keung,[158] M. Khakzad,[28] F. Khalil-zada,[10] H. Khandanyan,[165] A. Khanov,[112] D. Kharchenko,[65] A. Khodinov,[148] A. G. Kholodenko,[128] A. Khomich,[58a] T. J. Khoo,[27] G. Khoriauli,[20] A. Khoroshilov,[174] N. Khovanskiy,[65] V. Khovanskiy,[95] E. Khramov,[65] J. Khubua,[51] H. Kim,[7] M. S. Kim,[2] P. C. Kim,[143] S. H. Kim,[160] N. Kimura,[170] O. Kind,[15] B. T. King,[73] M. King,[67] R. S. B. King,[118] J. Kirk,[129] G. P. Kirsch,[118] L. E. Kirsch,[22] A. E. Kiryunin,[99] D. Kisielewska,[37] T. Kittelmann,[123] A. M. Kiver,[128] H. Kiyamura,[67] E. Kladiva,[144b] J. Klaiber-Lodewigs,[42] M. Klein,[73] U. Klein,[73] K. Kleinknecht,[81] M. Klemetti,[85] A. Klier,[171] A. Klimentov,[24] R. Klingenberg,[42] E. B. Klinkby,[35] T. Klioutchnikova,[29] P. F. Klok,[104] S. Klous,[105] E.-E. Kluge,[58a] T. Kluge,[73] P. Kluit,[105] S. Kluth,[99] E. Kneringer,[62] J. Knobloch,[29] E. B. F. G. Knoops,[83] A. Knue,[54] B. R. Ko,[44] T. Kobayashi,[155] M. Kobel,[43] B. Koblitz,[29] M. Kocian,[143] A. Kocnar,[113] P. Kodys,[126] K. Köneke,[29] A. C. König,[104] S. Koenig,[81] L. Köpke,[81] F. Koetsveld,[104] P. Koevesarki,[20] T. Koffas,[29] E. Koffeman,[105] F. Kohn,[54] Z. Kohout,[127] T. Kohriki,[66] T. Koi,[143] T. Kokott,[20] G. M. Kolachev,[107] H. Kolanoski,[15] V. Kolesnikov,[65] I. Koletsou,[89a] J. Koll,[88] D. Kollar,[29] M. Kollefrath,[48] S. D. Kolya,[82] A. A. Komar,[94] J. R. Komaragiri,[142] T. Kondo,[66] T. Kono,[41,o] A. I. Kononov,[48] R. Konoplich,[108,p] N. Konstantinidis,[77] A. Kootz,[174] S. Koperny,[37] S. V. Kopikov,[128] K. Korcyl,[38] K. Kordas,[154] V. Koreshev,[128] A. Korn,[14] A. Korol,[107] I. Korolkov,[11] E. V. Korolkova,[139] V. A. Korotkov,[128] O. Kortner,[99] S. Kortner,[99] V. V. Kostyukhin,[20] M. J. Kotamäki,[29] S. Kotov,[99] V. M. Kotov,[65] A. Kotwal,[44] C. Kourkoumelis,[8] V. Kouskoura,[154] A. Koutsman,[105] R. Kowalewski,[169] T. Z. Kowalski,[37] W. Kozanecki,[136] A. S. Kozhin,[128] V. Kral,[127] V. A. Kramarenko,[97] G. Kramberger,[74] O. Krasel,[42] M. W. Krasny,[78] A. Krasznahorkay,[108] J. Kraus,[88] A. Kreisel,[153] F. Krejci,[127] J. Kretzschmar,[73] N. Krieger,[54] P. Krieger,[158]

K. Kroeninger,[54] H. Kroha,[99] J. Kroll,[120] J. Kroseberg,[20] J. Krstic,[12a] U. Kruchonak,[65] H. Krüger,[20] Z. V. Krumshteyn,[65] A. Kruth,[20] T. Kubota,[155] S. Kuehn,[48] A. Kugel,[58c] T. Kuhl,[174] D. Kuhn,[62] V. Kukhtin,[65] Y. Kulchitsky,[90] S. Kuleshov,[31b] C. Kummer,[98] M. Kuna,[78] N. Kundu,[118] J. Kunkle,[120] A. Kupco,[125] H. Kurashige,[67] M. Kurata,[160] Y. A. Kurochkin,[90] V. Kus,[125] W. Kuykendall,[138] M. Kuze,[157] P. Kuzhir,[91] O. Kvasnicka,[125] J. Kvita,[29] R. Kwee,[15] A. La Rosa,[29] L. La Rotonda,[36a,36b] L. Labarga,[80] J. Labbe,[4] S. Lablak,[135a] C. Lacasta,[167] F. Lacava,[132a,132b] H. Lacker,[15] D. Lacour,[78] V. R. Lacuesta,[167] E. Ladygin,[65] R. Lafaye,[4] B. Laforge,[78] T. Lagouri,[80] S. Lai,[48] E. Laisne,[55] M. Lamanna,[29] C. L. Lampen,[6] W. Lampl,[6] E. Lancon,[136] U. Landgraf,[48] M. P. J. Landon,[75] H. Landsman,[152] J. L. Lane,[82] C. Lange,[41] A. J. Lankford,[163] F. Lanni,[24] K. Lantzsch,[29] V. V. Lapin,[128,a] S. Laplace,[78] C. Lapoire,[20] J. F. Laporte,[136] T. Lari,[89a] A. V. Larionov,[128] A. Larner,[118] C. Lasseur,[29] M. Lassnig,[29] W. Lau,[118] P. Laurelli,[47] A. Lavorato,[118] W. Lavrijsen,[14] P. Laycock,[73] A. B. Lazarev,[65] A. Lazzaro,[89a,89b] O. Le Dortz,[78] E. Le Guirriec,[83] C. Le Maner,[158] E. Le Menedeu,[136] A. Lebedev,[64] C. Lebel,[93] T. LeCompte,[5] F. Ledroit-Guillon,[55] H. Lee,[105] J. S. H. Lee,[150] S. C. Lee,[151] L. Lee,[175] M. Lefebvre,[169] M. Legendre,[136] A. Leger,[49] B. C. LeGeyt,[120] F. Legger,[98] C. Leggett,[14] M. Lehmacher,[20] G. Lehmann Miotto,[29] X. Lei,[6] M. A. L. Leite,[23b] R. Leitner,[126] D. Lellouch,[171] J. Lellouch,[78] M. Leltchouk,[34] V. Lendermann,[58a] K. J. C. Leney,[145b] T. Lenz,[174] G. Lenzen,[174] B. Lenzi,[136] K. Leonhardt,[43] S. Leontsinis,[9] C. Leroy,[93] J.-R. Lessard,[169] J. Lesser,[146a] C. G. Lester,[27] A. Leung Fook Cheong,[172] J. Levêque,[4] D. Levin,[87] L. J. Levinson,[171] M. S. Levitski,[128] M. Lewandowska,[21] A. Lewis,[118] G. H. Lewis,[108] A. M. Leyko,[20] M. Leyton,[15] B. Li,[83] H. Li,[172] S. Li,[32b,d] X. Li,[87] Z. Liang,[39] Z. Liang,[118,q] B. Liberti,[133a] P. Lichard,[29] M. Lichtnecker,[98] K. Lie,[165] W. Liebig,[13] R. Lifshitz,[152] J. N. Lilley,[17] C. Limbach,[20] A. Limosani,[86] M. Limper,[63] S. C. Lin,[151,r] F. Linde,[105] J. T. Linnemann,[88] E. Lipeles,[120] L. Lipinsky,[125] A. Lipniacka,[13] T. M. Liss,[165] D. Lissauer,[24] A. Lister,[49] A. M. Litke,[137] C. Liu,[28] D. Liu,[151,s] H. Liu,[87] J. B. Liu,[87] M. Liu,[32b] S. Liu,[2] Y. Liu,[32b] M. Livan,[119a,119b] S. S. A. Livermore,[118] A. Lleres,[55] J. Llorente Merino,[80] S. L. Lloyd,[75] E. Lobodzinska,[41] P. Loch,[6] W. S. Lockman,[137] S. Lockwitz,[175] T. Loddenkoetter,[20] F. K. Loebinger,[82] A. Loginov,[175] C. W. Loh,[168] T. Lohse,[15] K. Lohwasser,[48] M. Lokajicek,[125] J. Loken,[118] V. P. Lombardo,[4] R. E. Long,[71] L. Lopes,[124a,c] D. Lopez Mateos,[34,t] M. Losada,[162] P. Loscutoff,[14] F. Lo Sterzo,[132a,132b] M. J. Losty,[159a] X. Lou,[40] A. Lounis,[115] K. F. Loureiro,[162] J. Love,[21] P. A. Love,[71] A. J. Lowe,[143,f] F. Lu,[32a] L. Lu,[39] H. J. Lubatti,[138] C. Luci,[132a,132b] A. Lucotte,[55] A. Ludwig,[43] D. Ludwig,[41] I. Ludwig,[48] J. Ludwig,[48] F. Luehring,[61] G. Luijckx,[105] D. Lumb,[48] L. Luminari,[132a] E. Lund,[117] B. Lund-Jensen,[147] B. Lundberg,[79] J. Lundberg,[146a,146b] J. Lundquist,[35] M. Lungwitz,[81] A. Lupi,[122a,122b] G. Lutz,[99] D. Lynn,[24] J. Lys,[14] E. Lytken,[79] H. Ma,[24] L. L. Ma,[172] J. A. Macana Goia,[93] G. Maccarrone,[47] A. Macchiolo,[99] B. Maček,[74] J. Machado Miguens,[124a] D. Macina,[49] R. Mackeprang,[35] R. J. Madaras,[14] W. F. Mader,[43] R. Maenner,[58c] T. Maeno,[24] P. Mättig,[174] S. Mättig,[41] P. J. Magalhaes Martins,[124a,h] L. Magnoni,[29] E. Magradze,[54] Y. Mahalalel,[153] K. Mahboubi,[48] G. Mahout,[17] C. Maiani,[132a,132b] C. Maidantchik,[23a] A. Maio,[124a,c] S. Majewski,[24] Y. Makida,[66] N. Makovec,[115] P. Mal,[6] Pa. Malecki,[38] P. Malecki,[38] V. P. Maleev,[121] F. Malek,[55] U. Mallik,[63] D. Malon,[5] S. Maltezos,[9] V. Malyshev,[107] S. Malyukov,[29] R. Mameghani,[98] J. Mamuzic,[12b] A. Manabe,[66] L. Mandelli,[89a] I. Mandić,[74] R. Mandrysch,[15] J. Maneira,[124a] P. S. Mangeard,[88] I. D. Manjavidze,[65] A. Mann,[54] P. M. Manning,[137] A. Manousakis-Katsikakis,[8] B. Mansoulie,[136] A. Manz,[99] A. Mapelli,[29] L. Mapelli,[29] L. March,[80] J. F. Marchand,[29] F. Marchese,[133a,133b] G. Marchiori,[78] M. Marcisovsky,[125] A. Marin,[21,a] C. P. Marino,[61] F. Marroquim,[23a] R. Marshall,[82] Z. Marshall,[29] F. K. Martens,[158] S. Marti-Garcia,[167] A. J. Martin,[175] B. Martin,[29] B. Martin,[88] F. F. Martin,[120] J. P. Martin,[93] Ph. Martin,[55] T. A. Martin,[17] B. Martin dit Latour,[49] M. Martinez,[11] V. Martinez Outschoorn,[57] A. C. Martyniuk,[82] M. Marx,[82] F. Marzano,[132a] A. Marzin,[111] L. Masetti,[81] T. Mashimo,[155] R. Mashinistov,[94] J. Masik,[82] A. L. Maslennikov,[107] M. Maß,[42] I. Massa,[19a,19b] G. Massaro,[105] N. Massol,[4] P. Mastrandrea,[132a,132b] A. Mastroberardino,[36a,36b] T. Masubuchi,[155] M. Mathes,[20] P. Matricon,[115] H. Matsumoto,[155] H. Matsunaga,[155] T. Matsushita,[67] C. Mattravers,[118,u] J. M. Maugain,[29] S. J. Maxfield,[73] D. A. Maximov,[107] E. N. May,[5] A. Mayne,[139] R. Mazini,[151] M. Mazur,[20] M. Mazzanti,[89a] E. Mazzoni,[122a,122b] S. P. Mc Kee,[87] A. McCarn,[165] R. L. McCarthy,[148] T. G. McCarthy,[28] N. A. McCubbin,[129] K. W. McFarlane,[56] J. A. Mcfayden,[139] H. McGlone,[53] G. Mchedlidze,[51] R. A. McLaren,[29] T. Mclaughlan,[17] S. J. McMahon,[129] R. A. McPherson,[169,j] A. Meade,[84] J. Mechnich,[105] M. Mechtel,[174] M. Medinnis,[41] R. Meera-Lebbai,[111] T. Meguro,[116] R. Mehdiyev,[93] S. Mehlhase,[35] A. Mehta,[73] K. Meier,[58a] J. Meinhardt,[48] B. Meirose,[79] C. Melachrinos,[30] B. R. Mellado Garcia,[172] L. Mendoza Navas,[162] Z. Meng,[151,s] A. Mengarelli,[19a,19b] S. Menke,[99] C. Menot,[29] E. Meoni,[11] K. M. Mercurio,[57] P. Mermod,[118] L. Merola,[102a,102b] C. Meroni,[89a] F. S. Merritt,[30] A. Messina,[29] J. Metcalfe,[103] A. S. Mete,[64] S. Meuser,[20] C. Meyer,[81] J-P. Meyer,[136] J. Meyer,[173] J. Meyer,[54]

T. C. Meyer,[29] W. T. Meyer,[64] J. Miao,[32d] S. Michal,[29] L. Micu,[25a] R. P. Middleton,[129] P. Miele,[29] S. Migas,[73] L. Mijović,[41] G. Mikenberg,[171] M. Mikestikova,[125] M. Mikuž,[74] D. W. Miller,[143] R. J. Miller,[88] W. J. Mills,[168] C. Mills,[57] A. Milov,[171] D. A. Milstead,[146a,146b] D. Milstein,[171] A. A. Minaenko,[128] M. Miñano,[167] I. A. Minashvili,[65] A. I. Mincer,[108] B. Mindur,[37] M. Mineev,[65] Y. Ming,[130] L. M. Mir,[11] G. Mirabelli,[132a] L. Miralles Verge,[11] A. Misiejuk,[76] J. Mitrevski,[137] G. Y. Mitrofanov,[128] V. A. Mitsou,[167] S. Mitsui,[66] P. S. Miyagawa,[82] K. Miyazaki,[67] J. U. Mjörnmark,[79] T. Moa,[146a,146b] P. Mockett,[138] S. Moed,[57] V. Moeller,[27] K. Mönig,[41] N. Möser,[20] S. Mohapatra,[148] B. Mohn,[13] W. Mohr,[48] S. Mohrdieck-Möck,[99] A. M. Moisseev,[128,a] R. Moles-Valls,[167] J. Molina-Perez,[29] J. Monk,[77] E. Monnier,[83] S. Montesano,[89a,89b] F. Monticelli,[70] S. Monzani,[19a,19b] R. W. Moore,[2] G. F. Moorhead,[86] C. Mora Herrera,[49] A. Moraes,[53] A. Morais,[124a,c] N. Morange,[136] G. Morello,[36a,36b] D. Moreno,[81] M. Moreno Llácer,[167] P. Morettini,[50a] M. Morii,[57] J. Morin,[75] Y. Morita,[66] A. K. Morley,[29] G. Mornacchi,[29] M-C. Morone,[49] S. V. Morozov,[96] J. D. Morris,[75] H. G. Moser,[99] M. Mosidze,[51] J. Moss,[109] R. Mount,[143] E. Mountricha,[9] S. V. Mouraviev,[94] E. J. W. Moyse,[84] M. Mudrinic,[12b] F. Mueller,[58a] J. Mueller,[123] K. Mueller,[20] T. A. Müller,[98] D. Muenstermann,[29] A. Muijs,[105] A. Muir,[168] Y. Munwes,[153] K. Murakami,[66] W. J. Murray,[129] I. Mussche,[105] E. Musto,[102a,102b] A. G. Myagkov,[128] M. Myska,[125] J. Nadal,[11] K. Nagai,[160] K. Nagano,[66] Y. Nagasaka,[60] A. M. Nairz,[29] Y. Nakahama,[115] K. Nakamura,[155] I. Nakano,[110] G. Nanava,[20] A. Napier,[161] M. Nash,[77,u] N. R. Nation,[21] T. Nattermann,[20] T. Naumann,[41] G. Navarro,[162] H. A. Neal,[87] E. Nebot,[80] P. Yu. Nechaeva,[94] A. Negri,[119a,119b] G. Negri,[29] S. Nektarijevic,[49] A. Nelson,[64] S. Nelson,[143] T. K. Nelson,[143] S. Nemecek,[125] P. Nemethy,[108] A. A. Nepomuceno,[23a] M. Nessi,[29,v] S. Y. Nesterov,[121] M. S. Neubauer,[165] A. Neusiedl,[81] R. M. Neves,[108] P. Nevski,[24] P. R. Newman,[17] R. B. Nickerson,[118] R. Nicolaidou,[136] L. Nicolas,[139] B. Nicquevert,[29] F. Niedercorn,[115] J. Nielsen,[137] T. Niinikoski,[29] A. Nikiforov,[15] V. Nikolaenko,[128] K. Nikolaev,[65] I. Nikolic-Audit,[78] K. Nikolopoulos,[24] H. Nilsen,[48] P. Nilsson,[7] Y. Ninomiya,[155] A. Nisati,[132a] T. Nishiyama,[67] R. Nisius,[99] L. Nodulman,[5] M. Nomachi,[116] I. Nomidis,[154] H. Nomoto,[155] M. Nordberg,[29] B. Nordkvist,[146a,146b] P. R. Norton,[129] J. Novakova,[126] M. Nozaki,[66] M. Nožička,[41] L. Nozka,[113] I. M. Nugent,[159a] A.-E. Nuncio-Quiroz,[20] G. Nunes Hanninger,[20] T. Nunnemann,[98] E. Nurse,[77] T. Nyman,[29] B. J. O'Brien,[45] S. W. O'Neale,[17,a] D. C. O'Neil,[142] V. O'Shea,[53] F. G. Oakham,[28,e] H. Oberlack,[99] J. Ocariz,[78] A. Ochi,[67] S. Oda,[155] S. Odaka,[66] J. Odier,[83] H. Ogren,[61] A. Oh,[82] S. H. Oh,[44] C. C. Ohm,[146a,146b] T. Ohshima,[101] H. Ohshita,[140] T. K. Ohska,[66] T. Ohsugi,[59] S. Okada,[67] H. Okawa,[163] Y. Okumura,[101] T. Okuyama,[155] M. Olcese,[50a] A. G. Olchevski,[65] M. Oliveira,[124a,h] D. Oliveira Damazio,[24] E. Oliver Garcia,[167] D. Olivito,[120] A. Olszewski,[38] J. Olszowska,[38] C. Omachi,[67] A. Onofre,[124a,w] P. U. E. Onyisi,[30] C. J. Oram,[159a] M. J. Oreglia,[30] Y. Oren,[153] D. Orestano,[134a,134b] I. Orlov,[107] C. Oropeza Barrera,[53] R. S. Orr,[158] E. O. Ortega,[130] B. Osculati,[50a,50b] R. Ospanov,[120] C. Osuna,[11] G. Otero y Garzon,[26] J. P. Ottersbach,[105] M. Ouchrif,[135d] F. Ould-Saada,[117] A. Ouraou,[136] Q. Ouyang,[32a] M. Owen,[82] S. Owen,[139] O. K. Øye,[13] V. E. Ozcan,[18a] N. Ozturk,[7] A. Pacheco Pages,[11] C. Padilla Aranda,[11] E. Paganis,[139] F. Paige,[24] K. Pajchel,[117] S. Palestini,[29] D. Pallin,[33] A. Palma,[124a,c] J. D. Palmer,[17] Y. B. Pan,[172] E. Panagiotopoulou,[9] B. Panes,[31a] N. Panikashvili,[87] S. Panitkin,[24] D. Pantea,[25a] M. Panuskova,[125] V. Paolone,[123] A. Papadelis,[146a] Th. D. Papadopoulou,[9] A. Paramonov,[5] W. Park,[24,x] M. A. Parker,[27] F. Parodi,[50a,50b] J. A. Parsons,[34] U. Parzefall,[48] E. Pasqualucci,[132a] A. Passeri,[134a] F. Pastore,[134a,134b] Fr. Pastore,[29] G. Pásztor,[49,y] S. Pataraia,[172] N. Patel,[150] J. R. Pater,[82] S. Patricelli,[102a,102b] T. Pauly,[29] M. Pecsy,[144a] M. I. Pedraza Morales,[172] S. V. Peleganchuk,[107] H. Peng,[172] R. Pengo,[29] A. Penson,[34] J. Penwell,[61] M. Perantoni,[23a] K. Perez,[34,t] T. Perez Cavalcanti,[41] E. Perez Codina,[11] M. T. Pérez García-Estañ,[167] V. Perez Reale,[34] I. Peric,[20] L. Perini,[89a,89b] H. Pernegger,[29] R. Perrino,[72a] P. Perrodo,[4] S. Persembe,[3a] V. D. Peshekhonov,[65] O. Peters,[105] B. A. Petersen,[29] J. Petersen,[29] T. C. Petersen,[35] E. Petit,[83] A. Petridis,[154] C. Petridou,[154] E. Petrolo,[132a] F. Petrucci,[134a,134b] D. Petschull,[41] M. Petteni,[142] R. Pezoa,[31b] A. Phan,[86] A. W. Phillips,[27] P. W. Phillips,[129] G. Piacquadio,[29] E. Piccaro,[75] M. Piccinini,[19a,19b] A. Pickford,[53] S. M. Piec,[41] R. Piegaia,[26] J. E. Pilcher,[30] A. D. Pilkington,[82] J. Pina,[124a,c] M. Pinamonti,[164a,164c] A. Pinder,[118] J. L. Pinfold,[2] J. Ping,[32c] B. Pinto,[124a,c] O. Pirotte,[29] C. Pizio,[89a,89b] R. Placakyte,[41] M. Plamondon,[169] W. G. Plano,[82] M.-A. Pleier,[24] A. V. Pleskach,[128] A. Poblaguev,[24] S. Poddar,[58a] F. Podlyski,[33] L. Poggioli,[115] T. Poghosyan,[20] M. Pohl,[49] F. Polci,[55] G. Polesello,[119a] A. Policicchio,[138] A. Polini,[19a] J. Poll,[75] V. Polychronakos,[24] D. M. Pomarede,[136] D. Pomeroy,[22] K. Pommès,[29] L. Pontecorvo,[132a] B. G. Pope,[88] G. A. Popeneciu,[25a] D. S. Popovic,[12a] A. Poppleton,[29] X. Portell Bueso,[48] R. Porter,[163] C. Posch,[21] G. E. Pospelov,[99] S. Pospisil,[127] I. N. Potrap,[99] C. J. Potter,[149] C. T. Potter,[114] G. Poulard,[29] J. Poveda,[172] R. Prabhu,[77] P. Pralavorio,[83] A. Pranko,[14] S. Prasad,[57] R. Pravahan,[7] S. Prell,[64] K. Pretzl,[16] L. Pribyl,[29] D. Price,[61] L. E. Price,[5] M. J. Price,[29] P. M. Prichard,[73] D. Prieur,[123] M. Primavera,[72a] K. Prokofiev,[108] F. Prokoshin,[31b] S. Protopopescu,[24] J. Proudfoot,[5]

X. Prudent,[43] H. Przysiezniak,[4] S. Psoroulas,[20] E. Ptacek,[114] J. Purdham,[87] M. Purohit,[24,x] P. Puzo,[115]
Y. Pylypchenko,[117] J. Qian,[87] Z. Qian,[83] Z. Qin,[41] A. Quadt,[54] D. R. Quarrie,[14] W. B. Quayle,[172] F. Quinonez,[31a]
M. Raas,[104] V. Radescu,[58b] B. Radics,[20] T. Rador,[18a] F. Ragusa,[89a,89b] G. Rahal,[177] A. M. Rahimi,[109] D. Rahm,[24]
S. Rajagopalan,[24] M. Rammensee,[48] M. Rammes,[141] M. Ramstedt,[146a,146b] K. Randrianarivony,[28] P. N. Ratoff,[71]
F. Rauscher,[98] E. Rauter,[99] M. Raymond,[29] A. L. Read,[117] D. M. Rebuzzi,[119a,119b] A. Redelbach,[173] G. Redlinger,[24]
R. Reece,[120] K. Reeves,[40] A. Reichold,[105] E. Reinherz-Aronis,[153] A. Reinsch,[114] I. Reisinger,[42] D. Reljic,[12a]
C. Rembser,[29] Z. L. Ren,[151] A. Renaud,[115] P. Renkel,[39] B. Rensch,[35] M. Rescigno,[132a] S. Resconi,[89a] B. Resende,[136]
P. Reznicek,[98] R. Rezvani,[158] A. Richards,[77] R. Richter,[99] E. Richter-Was,[38,z] M. Ridel,[78] S. Rieke,[81] M. Rijpstra,[105]
M. Rijssenbeek,[148] A. Rimoldi,[119a,119b] L. Rinaldi,[19a] R. R. Rios,[39] I. Riu,[11] G. Rivoltella,[89a,89b] F. Rizatdinova,[112]
E. Rizvi,[75] S. H. Robertson,[85,j] A. Robichaud-Veronneau,[49] D. Robinson,[27] J. E. M. Robinson,[77] M. Robinson,[114]
A. Robson,[53] J. G. Rocha de Lima,[106] C. Roda,[122a,122b] D. Roda Dos Santos,[29] S. Rodier,[80] D. Rodriguez,[162]
Y. Rodriguez Garcia,[15] A. Roe,[54] S. Roe,[29] O. Røhne,[117] V. Rojo,[1] S. Rolli,[161] A. Romaniouk,[96] V. M. Romanov,[65]
G. Romeo,[26] D. Romero Maltrana,[31a] L. Roos,[78] E. Ros,[167] S. Rosati,[132a,132b] K. Rosbach,[49] M. Rose,[76]
G. A. Rosenbaum,[158] E. I. Rosenberg,[64] P. L. Rosendahl,[13] L. Rosselet,[49] V. Rossetti,[11] E. Rossi,[102a,102b]
L. P. Rossi,[50a] L. Rossi,[89a,89b] M. Rotaru,[25a] I. Roth,[171] J. Rothberg,[138] D. Rousseau,[115] C. R. Royon,[136]
A. Rozanov,[83] Y. Rozen,[152] X. Ruan,[115] I. Rubinskiy,[41] B. Ruckert,[98] N. Ruckstuhl,[105] V. I. Rud,[97] G. Rudolph,[62]
F. Rühr,[6] F. Ruggieri,[134a,134b] A. Ruiz-Martinez,[64] E. Rulikowska-Zarebska,[37] V. Rumiantsev,[91,a] L. Rumyantsev,[65]
K. Runge,[48] O. Runolfsson,[20] Z. Rurikova,[48] N. A. Rusakovich,[65] D. R. Rust,[61] J. P. Rutherfoord,[6] C. Ruwiedel,[14]
P. Ruzicka,[125] Y. F. Ryabov,[121] V. Ryadovikov,[128] P. Ryan,[88] M. Rybar,[126] G. Rybkin,[115] N. C. Ryder,[118] S. Rzaeva,[10]
A. F. Saavedra,[150] I. Sadeh,[153] H. F-W. Sadrozinski,[137] R. Sadykov,[65] F. Safai Tehrani,[132a,132b] H. Sakamoto,[155]
G. Salamanna,[105] A. Salamon,[133a] M. Saleem,[111] D. Salihagic,[99] A. Salnikov,[143] J. Salt,[167]
B. M. Salvachua Ferrando,[5] D. Salvatore,[36a,36b] F. Salvatore,[149] A. Salvucci,[104] A. Salzburger,[29] D. Sampsonidis,[154]
B. H. Samset,[117] H. Sandaker,[13] H. G. Sander,[81] M. P. Sanders,[98] M. Sandhoff,[174] P. Sandhu,[158] T. Sandoval,[27]
R. Sandstroem,[105] S. Sandvoss,[174] D. P. C. Sankey,[129] A. Sansoni,[47] C. Santamarina Rios,[85] C. Santoni,[33]
R. Santonico,[133a,133b] H. Santos,[124a] J. G. Saraiva,[124a,c] T. Sarangi,[172] E. Sarkisyan-Grinbaum,[7] F. Sarri,[122a,122b]
G. Sartisohn,[174] O. Sasaki,[66] T. Sasaki,[66] N. Sasao,[68] I. Satsounkevitch,[90] G. Sauvage,[4] J. B. Sauvan,[115]
P. Savard,[158,e] V. Savinov,[123] D. O. Savu,[29] P. Savva,[9] L. Sawyer,[24,l] D. H. Saxon,[53] L. P. Says,[33] C. Sbarra,[19a,19b]
A. Sbrizzi,[19a,19b] O. Scallon,[93] D. A. Scannicchio,[163] J. Schaarschmidt,[115] P. Schacht,[99] U. Schäfer,[81] S. Schaepe,[20]
S. Schaetzel,[58b] A. C. Schaffer,[115] D. Schaile,[98] R. D. Schamberger,[148] A. G. Schamov,[107] V. Scharf,[58a]
V. A. Schegelsky,[121] D. Scheirich,[87] M. I. Scherzer,[14] C. Schiavi,[50a,50b] J. Schieck,[98] M. Schioppa,[36a,36b]
S. Schlenker,[29] J. L. Schlereth,[5] E. Schmidt,[48] M. P. Schmidt,[175,a] K. Schmieden,[20] C. Schmitt,[81] S. Schmitt,[58b]
M. Schmitz,[20] A. Schöning,[58b] M. Schott,[29] D. Schouten,[142] J. Schovancova,[125] M. Schram,[85] C. Schroeder,[81]
N. Schroer,[58c] S. Schuh,[29] G. Schuler,[29] J. Schultes,[174] H.-C. Schultz-Coulon,[58a] H. Schulz,[15] J. W. Schumacher,[20]
M. Schumacher,[48] B. A. Schumm,[137] Ph. Schune,[136] C. Schwanenberger,[82] A. Schwartzman,[143] Ph. Schwemling,[78]
R. Schwienhorst,[88] R. Schwierz,[43] J. Schwindling,[136] W. G. Scott,[129] J. Searcy,[114] E. Sedykh,[121] E. Segura,[11]
S. C. Seidel,[103] A. Seiden,[137] F. Seifert,[43] J. M. Seixas,[23a] G. Sekhniaidze,[102a] D. M. Seliverstov,[121] B. Sellden,[146a]
G. Sellers,[73] M. Seman,[144b] N. Semprini-Cesari,[19a,19b] C. Serfon,[98] L. Serin,[115] R. Seuster,[99] H. Severini,[111]
M. E. Sevior,[86] A. Sfyrla,[29] E. Shabalina,[54] M. Shamim,[114] L. Y. Shan,[32a] J. T. Shank,[21] Q. T. Shao,[86] M. Shapiro,[14]
P. B. Shatalov,[95] L. Shaver,[6] C. Shaw,[53] K. Shaw,[164a,164c] D. Sherman,[175] P. Sherwood,[77] A. Shibata,[108] S. Shimizu,[29]
M. Shimojima,[100] T. Shin,[56] A. Shmeleva,[94] M. J. Shochet,[30] D. Short,[118] M. A. Shupe,[6] P. Sicho,[125]
A. Sidoti,[132a,132b] A. Siebel,[174] F. Siegert,[48] J. Siegrist,[14] Dj. Sijacki,[12a] O. Silbert,[171] J. Silva,[124a,c] Y. Silver,[153]
D. Silverstein,[143] S. B. Silverstein,[146a] V. Simak,[127] O. Simard,[136] Lj. Simic,[12a] S. Simion,[115] B. Simmons,[77]
M. Simonyan,[35] P. Sinervo,[158] N. B. Sinev,[114] V. Sipica,[141] G. Siragusa,[81] A. N. Sisakyan,[65] S. Yu. Sivoklokov,[97]
J. Sjölin,[146a,146b] T. B. Sjursen,[13] L. A. Skinnari,[14] K. Skovpen,[107] P. Skubic,[111] N. Skvorodnev,[22] M. Slater,[17]
T. Slavicek,[127] K. Sliwa,[161] T. J. Sloan,[71] J. Sloper,[29] V. Smakhtin,[171] S. Yu. Smirnov,[96] L. N. Smirnova,[97]
O. Smirnova,[79] B. C. Smith,[57] D. Smith,[143] K. M. Smith,[53] M. Smizanska,[71] K. Smolek,[127] A. A. Snesarev,[94]
S. W. Snow,[82] J. Snow,[111] J. Snuverink,[105] S. Snyder,[24] M. Soares,[124a] R. Sobie,[169,j] J. Sodomka,[127] A. Soffer,[153]
C. A. Solans,[167] M. Solar,[127] J. Solc,[127] E. Soldatov,[96] U. Soldevila,[167] E. Solfaroli Camillocci,[132a,132b]
A. A. Solodkov,[128] O. V. Solovyanov,[128] J. Sondericker,[24] N. Soni,[2] V. Sopko,[127] B. Sopko,[127] M. Sorbi,[89a,89b]
M. Sosebee,[7] A. Soukharev,[107] S. Spagnolo,[72a,72b] F. Spanò,[34] R. Spighi,[19a] G. Spigo,[29] F. Spila,[132a,132b]
E. Spiriti,[134a] R. Spiwoks,[29] M. Spousta,[126] T. Spreitzer,[158] B. Spurlock,[7] R. D. St. Denis,[53] T. Stahl,[141]

J. Stahlman,[120] R. Stamen,[58a] E. Stanecka,[29] R. W. Stanek,[5] C. Stanescu,[134a] S. Stapnes,[117] E. A. Starchenko,[128] J. Stark,[55] P. Staroba,[125] P. Starovoitov,[91] A. Staude,[98] P. Stavina,[144a] G. Stavropoulos,[14] G. Steele,[53] P. Steinbach,[43] P. Steinberg,[24] I. Stekl,[127] B. Stelzer,[142] H. J. Stelzer,[41] O. Stelzer-Chilton,[159a] H. Stenzel,[52] K. Stevenson,[75] G. A. Stewart,[53] J. A. Stillings,[20] T. Stockmanns,[20] M. C. Stockton,[29] K. Stoerig,[48] G. Stoicea,[25a] S. Stonjek,[99] P. Strachota,[126] A. R. Stradling,[7] A. Straessner,[43] J. Strandberg,[147] S. Strandberg,[146a,146b] A. Strandlie,[117] M. Strang,[109] E. Strauss,[143] M. Strauss,[111] P. Strizenec,[144b] R. Ströhmer,[173] D. M. Strom,[114] J. A. Strong,[76,a] R. Stroynowski,[39] J. Strube,[129] B. Stugu,[13] I. Stumer,[24,a] J. Stupak,[148] P. Sturm,[174] D. A. Soh,[151,q] D. Su,[143] HS. Subramania,[2] A. Succurro,[11] Y. Sugaya,[116] T. Sugimoto,[101] C. Suhr,[106] K. Suita,[67] M. Suk,[126] V. V. Sulin,[94] S. Sultansoy,[3d] T. Sumida,[29] X. Sun,[55] J. E. Sundermann,[48] K. Suruliz,[164a,164b] S. Sushkov,[11] G. Susinno,[36a,36b] M. R. Sutton,[139] Y. Suzuki,[66] M. Svatos,[125] Yu. M. Sviridov,[128] S. Swedish,[168] I. Sykora,[144a] T. Sykora,[126] B. Szeless,[29] J. Sánchez,[167] D. Ta,[105] K. Tackmann,[41] A. Taffard,[163] R. Tafirout,[159a] A. Taga,[117] N. Taiblum,[153] Y. Takahashi,[101] H. Takai,[24] R. Takashima,[69] H. Takeda,[67] T. Takeshita,[140] M. Talby,[83] A. Talyshev,[107] M. C. Tamsett,[24] J. Tanaka,[155] R. Tanaka,[115] S. Tanaka,[131] S. Tanaka,[66] Y. Tanaka,[100] K. Tani,[67] N. Tannoury,[83] G. P. Tappern,[29] S. Tapprogge,[81] D. Tardif,[158] S. Tarem,[152] F. Tarrade,[24] G. F. Tartarelli,[89a] P. Tas,[126] M. Tasevsky,[125] E. Tassi,[36a,36b] M. Tatarkhanov,[14] C. Taylor,[77] F. E. Taylor,[92] G. N. Taylor,[86] W. Taylor,[159b] M. Teixeira Dias Castanheira,[75] P. Teixeira-Dias,[76] K. K. Temming,[48] H. Ten Kate,[29] P. K. Teng,[151] S. Terada,[66] K. Terashi,[155] J. Terron,[80] M. Terwort,[41,o] M. Testa,[47] R. J. Teuscher,[158,j] J. Thadome,[174] J. Therhaag,[20] T. Theveneaux-Pelzer,[78] M. Thioye,[175] S. Thoma,[48] J. P. Thomas,[17] E. N. Thompson,[84] P. D. Thompson,[17] P. D. Thompson,[158] A. S. Thompson,[53] E. Thomson,[120] M. Thomson,[27] R. P. Thun,[87] T. Tic,[125] V. O. Tikhomirov,[94] Y. A. Tikhonov,[107] C. J. W. P. Timmermans,[104] P. Tipton,[175] F. J. Tique Aires Viegas,[29] S. Tisserant,[83] J. Tobias,[48] B. Toczek,[37] T. Todorov,[4] S. Todorova-Nova,[161] B. Toggerson,[163] J. Tojo,[66] S. Tokár,[144a] K. Tokunaga,[67] K. Tokushuku,[66] K. Tollefson,[88] M. Tomoto,[101] L. Tompkins,[14] K. Toms,[103] G. Tong,[32a] A. Tonoyan,[13] C. Topfel,[16] N. D. Topilin,[65] I. Torchiani,[29] E. Torrence,[114] E. Torró Pastor,[167] J. Toth,[83,y] F. Touchard,[83] D. R. Tovey,[139] D. Traynor,[75] T. Trefzger,[173] J. Treis,[20] L. Tremblet,[29] A. Tricoli,[29] I. M. Trigger,[159a] S. Trincaz-Duvoid,[78] T. N. Trinh,[78] M. F. Tripiana,[70] N. Triplett,[64] W. Trischuk,[158] A. Trivedi,[24,x] B. Trocmé,[55] C. Troncon,[89a] M. Trottier-McDonald,[142] A. Trzupek,[38] C. Tsarouchas,[29] J. C-L. Tseng,[118] M. Tsiakiris,[105] P. V. Tsiareshka,[90] D. Tsionou,[4] G. Tsipolitis,[9] V. Tsiskaridze,[48] E. G. Tskhadadze,[51] I. I. Tsukerman,[95] V. Tsulaia,[123] J.-W. Tsung,[20] S. Tsuno,[66] D. Tsybychev,[148] A. Tua,[139] J. M. Tuggle,[30] M. Turala,[38] D. Turecek,[127] I. Turk Cakir,[3e] E. Turlay,[105] R. Turra,[89a,89b] P. M. Tuts,[34] A. Tykhonov,[74] M. Tylmad,[146a,146b] M. Tyndel,[129] H. Tyrvainen,[29] G. Tzanakos,[8] K. Uchida,[20] I. Ueda,[155] R. Ueno,[28] M. Ugland,[13] M. Uhlenbrock,[20] M. Uhrmacher,[54] F. Ukegawa,[160] G. Unal,[29] D. G. Underwood,[5] A. Undrus,[24] G. Unel,[163] Y. Unno,[66] D. Urbaniec,[34] E. Urkovsky,[153] P. Urrejola,[31a] G. Usai,[7] M. Uslenghi,[119a,119b] L. Vacavant,[83] V. Vacek,[127] B. Vachon,[85] S. Vahsen,[14] J. Valenta,[125] P. Valente,[132a] S. Valentinetti,[19a,19b] S. Valkar,[126] E. Valladolid Gallego,[167] S. Vallecorsa,[152] J. A. Valls Ferrer,[167] H. van der Graaf,[105] E. van der Kraaij,[105] R. Van Der Leeuw,[105] E. van der Poel,[105] D. van der Ster,[29] B. Van Eijk,[105] N. van Eldik,[84] P. van Gemmeren,[5] Z. van Kesteren,[105] I. van Vulpen,[105] W. Vandelli,[29] G. Vandoni,[29] A. Vaniachine,[5] P. Vankov,[41] F. Vannucci,[78] F. Varela Rodriguez,[29] R. Vari,[132a] E. W. Varnes,[6] D. Varouchas,[14] A. Vartapetian,[7] K. E. Varvell,[150] V. I. Vassilakopoulos,[56] F. Vazeille,[33] G. Vegni,[89a,89b] J. J. Veillet,[115] C. Vellidis,[8] F. Veloso,[124a] R. Veness,[29] S. Veneziano,[132a] A. Ventura,[72a,72b] D. Ventura,[138] M. Venturi,[48] N. Venturi,[16] V. Vercesi,[119a] M. Verducci,[138] W. Verkerke,[105] J. C. Vermeulen,[105] A. Vest,[43] M. C. Vetterli,[142,e] I. Vichou,[165] T. Vickey,[145b,aa] G. H. A. Viehhauser,[118] S. Viel,[168] M. Villa,[19a,19b] M. Villaplana Perez,[167] E. Vilucchi,[47] M. G. Vincter,[28] E. Vinek,[29] V. B. Vinogradov,[65] M. Virchaux,[136,a] S. Viret,[33] J. Virzi,[14] A. Vitale,[19a,19b] O. Vitells,[171] M. Viti,[41] I. Vivarelli,[48] F. Vives Vaque,[11] S. Vlachos,[9] M. Vlasak,[127] N. Vlasov,[20] A. Vogel,[20] P. Vokac,[127] G. Volpi,[47] M. Volpi,[11] G. Volpini,[89a] H. von der Schmitt,[99] J. von Loeben,[99] H. von Radziewski,[48] E. von Toerne,[20] V. Vorobel,[126] A. P. Vorobiev,[128] V. Vorwerk,[11] M. Vos,[167] R. Voss,[29] T. T. Voss,[174] J. H. Vossebeld,[73] N. Vranjes,[12a] M. Vranjes Milosavljevic,[12a] V. Vrba,[125] M. Vreeswijk,[105] T. Vu Anh,[81] R. Vuillermet,[29] I. Vukotic,[115] W. Wagner,[174] P. Wagner,[120] H. Wahlen,[174] J. Wakabayashi,[101] J. Walbersloh,[42] S. Walch,[87] J. Walder,[71] R. Walker,[98] W. Walkowiak,[141] R. Wall,[175] P. Waller,[73] C. Wang,[44] H. Wang,[172] H. Wang,[32b,bb] J. Wang,[151] J. Wang,[32d] J. C. Wang,[138] R. Wang,[103] S. M. Wang,[151] A. Warburton,[85] C. P. Ward,[27] M. Warsinsky,[48] P. M. Watkins,[17] A. T. Watson,[17] M. F. Watson,[17] G. Watts,[138] S. Watts,[82] A. T. Waugh,[150] B. M. Waugh,[77] J. Weber,[42] M. Weber,[129] M. S. Weber,[16] P. Weber,[54] A. R. Weidberg,[118] P. Weigell,[99] J. Weingarten,[54] C. Weiser,[48] H. Wellenstein,[22] P. S. Wells,[29] M. Wen,[47] T. Wenaus,[24] S. Wendler,[123] Z. Weng,[151,q] T. Wengler,[29] S. Wenig,[29] N. Wermes,[20]

M. Werner,[48] P. Werner,[29] M. Werth,[163] M. Wessels,[58a] C. Weydert,[55] K. Whalen,[28] S. J. Wheeler-Ellis,[163] S. P. Whitaker,[21] A. White,[7] M. J. White,[86] S. White,[24] S. R. Whitehead,[118] D. Whiteson,[163] D. Whittington,[61] F. Wicek,[115] D. Wicke,[174] F. J. Wickens,[129] W. Wiedenmann,[172] M. Wielers,[129] P. Wienemann,[20] L. A. M. Wiik,[48] P. A. Wijeratne,[77] A. Wildauer,[167] M. A. Wildt,[41,o] I. Wilhelm,[126] H. G. Wilkens,[29] J. Z. Will,[98] E. Williams,[34] H. H. Williams,[120] W. Willis,[34] S. Willocq,[84] J. A. Wilson,[17] M. G. Wilson,[143] A. Wilson,[87] I. Wingerter-Seez,[4] S. Winkelmann,[48] F. Winklmeier,[29] M. Wittgen,[143] M. W. Wolter,[38] H. Wolters,[124a,h] G. Wooden,[118] B. K. Wosiek,[38] J. Wotschack,[29] M. J. Woudstra,[84] K. Wraight,[53] C. Wright,[53] B. Wrona,[73] S. L. Wu,[172] X. Wu,[49] Y. Wu,[32b,cc] E. Wulf,[34] R. Wunstorf,[42] B. M. Wynne,[45] L. Xaplanteris,[9] S. Xella,[35] S. Xie,[48] Y. Xie,[32a] C. Xu,[32b,dd] D. Xu,[139] G. Xu,[32a] B. Yabsley,[150] M. Yamada,[66] A. Yamamoto,[66] K. Yamamoto,[64] S. Yamamoto,[155] T. Yamamura,[155] J. Yamaoka,[44] T. Yamazaki,[155] Y. Yamazaki,[67] Z. Yan,[21] H. Yang,[87] U. K. Yang,[82] Y. Yang,[61] Y. Yang,[32a] Z. Yang,[146a,146b] S. Yanush,[91] W-M. Yao,[14] Y. Yao,[14] Y. Yasu,[66] G. V. Ybeles Smit,[130] J. Ye,[39] S. Ye,[24] M. Yilmaz,[3c] R. Yoosoofmiya,[123] K. Yorita,[170] R. Yoshida,[5] C. Young,[143] S. Youssef,[21] D. Yu,[24] J. Yu,[7] J. Yu,[32c,dd] L. Yuan,[32a,ee] A. Yurkewicz,[148] V. G. Zaets,[128] R. Zaidan,[63] A. M. Zaitsev,[128] Z. Zajacova,[29] Yo. K. Zalite,[121] L. Zanello,[132a,132b] P. Zarzhitsky,[39] A. Zaytsev,[107] C. Zeitnitz,[174] M. Zeller,[175] A. Zemla,[38] C. Zendler,[20] A. V. Zenin,[128] O. Zenin,[128] T. Ženiš,[144a] Z. Zenonos,[122a,122b] S. Zenz,[14] D. Zerwas,[115] G. Zevi della Porta,[57] Z. Zhan,[32d] D. Zhang,[32b,bb] H. Zhang,[88] J. Zhang,[5] X. Zhang,[32d] Z. Zhang,[115] L. Zhao,[108] T. Zhao,[138] Z. Zhao,[32b] A. Zhemchugov,[65] S. Zheng,[32a] J. Zhong,[151,ff] B. Zhou,[87] N. Zhou,[163] Y. Zhou,[151] C. G. Zhu,[32d] H. Zhu,[41] Y. Zhu,[172] X. Zhuang,[98] V. Zhuravlov,[99] D. Zieminska,[61] R. Zimmermann,[20] S. Zimmermann,[20] S. Zimmermann,[48] M. Ziolkowski,[141] R. Zitoun,[4] L. Živković,[34] V. V. Zmouchko,[128,a] G. Zobernig,[172] A. Zoccoli,[19a,19b] Y. Zolnierowski,[4] A. Zsenei,[29] M. zur Nedden,[15] V. Zutshi,[106] and L. Zwalinski[29]

(ATLAS Collaboration)

[1]*University at Albany, Albany, New York, USA*
[2]*Department of Physics, University of Alberta, Edmonton AB, Canada*
[3a]*Department of Physics, Ankara University, Ankara, Turkey*
[3b]*Department of Physics, Dumlupinar University, Kutahya, Turkey*
[3c]*Department of Physics, Gazi University, Ankara, Turkey*
[3d]*Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey*
[3e]*Turkish Atomic Energy Authority, Ankara, Turkey*
[4]*LAPP, CNRS/IN2P3 and Université de Savoie, Annecy-le-Vieux, France*
[5]*High Energy Physics Division, Argonne National Laboratory, Argonne, Illinois, USA*
[6]*Department of Physics, University of Arizona, Tucson Arizona, USA*
[7]*Department of Physics, The University of Texas at Arlington, Arlington Texas, USA*
[8]*Physics Department, University of Athens, Athens, Greece*
[9]*Physics Department, National Technical University of Athens, Zografou, Greece*
[10]*Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan*
[11]*Institut de Física d'Altes Energies and Universitat Autònoma de Barcelona and ICREA, Barcelona, Spain*
[12a]*Institute of Physics, University of Belgrade, Belgrade, Serbia*
[12b]*Vinca Institute of Nuclear Sciences, Belgrade, Serbia*
[13]*Department for Physics and Technology, University of Bergen, Bergen, Norway*
[14]*Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley California, USA*
[15]*Department of Physics, Humboldt University, Berlin, Germany*
[16]*Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland*
[17]*School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom*
[18a]*Department of Physics, Bogazici University, Istanbul, Turkey*
[18b]*Division of Physics, Dogus University, Istanbul, Turkey*
[18c]*Department of Physics Engineering, Gaziantep University, Gaziantep, Turkey*
[18d]*Department of Physics, Istanbul Technical University, Istanbul, Turkey*
[19a]*INFN Sezione di Bologna, Italy*
[19b]*Dipartimento di Fisica, Università di Bologna, Bologna, Italy*
[20]*Physikalisches Institut, University of Bonn, Bonn, Germany*
[21]*Department of Physics, Boston University, Boston, Massachusetts, USA*
[22]*Department of Physics, Brandeis University, Waltham, Massachusetts, USA*
[23a]*Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro, Brazil*
[23b]*Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil*

[24]Physics Department, Brookhaven National Laboratory, Upton, New York, USA
[25a]National Institute of Physics and Nuclear Engineering, Bucharest, Romania
[25b]University Politehnica Bucharest, Bucharest, Romania
[25c]West University in Timisoara, Timisoara, Romania
[26]Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina
[27]Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom
[28]Department of Physics, Carleton University, Ottawa ON, Canada
[29]CERN, Geneva, Switzerland
[30]Enrico Fermi Institute, University of Chicago, Chicago, Illinois, USA
[31a]Departamento de Fisica, Pontificia Universidad Católica de Chile, Santiago, Chile
[31b]Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile
[32a]Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China
[32b]Department of Modern Physics, University of Science and Technology of China, Anhui, China
[32c]Department of Physics, Nanjing University, Jiangsu, China
[32d]High Energy Physics Group, Shandong University, Shandong, China
[33]Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Aubiere Cedex, France
[34]Nevis Laboratory, Columbia University, Irvington, New York, USA
[35]Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark
[36a]INFN Gruppo Collegato di Cosenza, Italy
[36b]Dipartimento di Fisica, Università della Calabria, Arcavata di Rende, Italy
[37]Faculty of Physics and Applied Computer Science, AGH-University of Science and Technology, Krakow, Poland
[38]The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland
[39]Physics Department, Southern Methodist University, Dallas, Texas, USA
[40]Physics Department, University of Texas at Dallas, Richardson, Texas, USA
[41]DESY, Hamburg and Zeuthen, Germany
[42]Institut für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany
[43]Institut für Kern- und Teilchenphysik, Technical University Dresden, Dresden, Germany
[44]Department of Physics, Duke University, Durham, North Carolina, USA
[45]SUPA - School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom
[46]Fachhochschule Wiener Neustadt, Wiener Neustadt, Austria
[47]INFN Laboratori Nazionali di Frascati, Frascati, Italy
[48]Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg i.Br., Germany
[49]Section de Physique, Université de Genève, Geneva, Switzerland
[50a]INFN Sezione di Genova, Italy
[50b]Dipartimento di Fisica, Università di Genova, Genova, Italy
[51]Institute of Physics and HEP Institute, Georgian Academy of Sciences and Tbilisi State University, Tbilisi, Georgia
[52]II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany
[53]SUPA - School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom
[54]II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany
[55]Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier and CNRS/IN2P3 and Institut National Polytechnique de Grenoble, Grenoble, France
[56]Department of Physics, Hampton University, Hampton, Virginia, USA
[57]Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, Massachusetts, USA
[58a]Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany
[58b]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg, Germany
[58c]ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany
[59]Faculty of Science, Hiroshima University, Hiroshima, Japan
[60]Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan
[61]Department of Physics, Indiana University, Bloomington, Indiana, USA
[62]Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria
[63]University of Iowa, Iowa City, Iowa, USA
[64]Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA
[65]Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia
[66]KEK, High Energy Accelerator Research Organization, Tsukuba, Japan
[67]Graduate School of Science, Kobe University, Kobe, Japan
[68]Faculty of Science, Kyoto University, Kyoto, Japan
[69]Kyoto University of Education, Kyoto, Japan
[70]Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina
[71]Physics Department, Lancaster University, Lancaster, United Kingdom
[72a]INFN Sezione di Lecce, Italy

[72b]Dipartimento di Fisica, Università del Salento, Lecce, Italy
[73]Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom
[74]Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia
[75]Department of Physics, Queen Mary University of London, London, United Kingdom
[76]Department of Physics, Royal Holloway University of London, Surrey, United Kingdom
[77]Department of Physics and Astronomy, University College London, London, United Kingdom
[78]Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
[79]Fysiska institutionen, Lunds universitet, Lund, Sweden
[80]Departamento de Fisica Teorica C-15, Universidad Autonoma de Madrid, Madrid, Spain
[81]Institut für Physik, Universität Mainz, Mainz, Germany
[82]School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom
[83]CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
[84]Department of Physics, University of Massachusetts, Amherst, Massachusetts, USA
[85]Department of Physics, McGill University, Montreal QC, Canada
[86]School of Physics, University of Melbourne, Victoria, Australia
[87]Department of Physics, The University of Michigan, Ann Arbor, Michigan, USA
[88]Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA
[89a]INFN Sezione di Milano, Italy
[89b]Dipartimento di Fisica, Università di Milano, Milano, Italy
[90]B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Republic of Belarus
[91]National Scientific and Educational Center for Particle and High Energy Physics, Minsk, Republic of Belarus
[92]Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA
[93]Group of Particle Physics, University of Montreal, Montreal QC, Canada
[94]P.N. Lebedev Institute of Physics, Academy of Sciences, Moscow, Russia
[95]Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia
[96]Moscow Engineering and Physics Institute (MEPhI), Moscow, Russia
[97]Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia
[98]Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany
[99]Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany
[100]Nagasaki Institute of Applied Science, Nagasaki, Japan
[101]Graduate School of Science, Nagoya University, Nagoya, Japan
[102a]INFN Sezione di Napoli, Italy
[102b]Dipartimento di Scienze Fisiche, Università di Napoli, Napoli, Italy
[103]Department of Physics and Astronomy, University of New Mexico, Albuquerque, New Mexico, USA
[104]Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands
[105]Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands
[106]Department of Physics, Northern Illinois University, DeKalb, Illinois, USA
[107]Budker Institute of Nuclear Physics (BINP), Novosibirsk, Russia
[108]Department of Physics, New York University, New York, New York, USA
[109]Ohio State University, Columbus, Ohio, USA
[110]Faculty of Science, Okayama University, Okayama, Japan
[111]Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, Oklahoma, USA
[112]Department of Physics, Oklahoma State University, Stillwater, Oklahoma, USA
[113]Palacký University, RCPTM, Olomouc, Czech Republic
[114]Center for High Energy Physics, University of Oregon, Eugene, Oregon, USA
[115]LAL, Univ. Paris-Sud and CNRS/IN2P3, Orsay, France
[116]Graduate School of Science, Osaka University, Osaka, Japan
[117]Department of Physics, University of Oslo, Oslo, Norway
[118]Department of Physics, Oxford University, Oxford, United Kingdom
[119a]INFN Sezione di Pavia, Italy
[119b]Dipartimento di Fisica Nucleare e Teorica, Università di Pavia, Pavia, Italy
[120]Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania, USA
[121]Petersburg Nuclear Physics Institute, Gatchina, Russia
[122a]INFN Sezione di Pisa, Italy
[122b]Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy
[123]Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, Pennsylvania, USA
[124a]Laboratorio de Instrumentacao e Fisica Experimental de Particulas - LIP, Lisboa, Portugal
[124b]Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada, Portugal
[125]Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czech Republic
[126]Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czech Republic
[127]Czech Technical University in Prague, Praha, Czech Republic

[128]State Research Center Institute for High Energy Physics, Protvino, Russia
[129]Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom
[130]Physics Department, University of Regina, Regina SK, Canada
[131]Ritsumeikan University, Kusatsu, Shiga, Japan
[132a]INFN Sezione di Roma I, Italy
[132b]Dipartimento di Fisica, Università La Sapienza, Roma, Italy
[133a]INFN Sezione di Roma Tor Vergata, Italy
[133b]Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy
[134a]INFN Sezione di Roma Tre, Italy
[134b]Dipartimento di Fisica, Università Roma Tre, Roma, Italy
[135a]Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies - Université Hassan II, Casablanca, Morocco
[135b] Center National de l'Energie des Sciences Techniques Nucleaires, Rabat, Morocco
[135c]Université Cadi Ayyad, Faculté des sciences Semlalia Département de Physique, B.P. 2390 Marrakech 40000, Morocco
[135d]Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda, Morocco
[135e]Faculté des Sciences, Université Mohammed V, Rabat, Morocco
[136]DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat a l'Energie Atomique), Gif-sur-Yvette, France
[137]Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, California, USA
[138]Department of Physics, University of Washington, Seattle, Washington, USA
[139]Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom
[140]Department of Physics, Shinshu University, Nagano, Japan
[141]Fachbereich Physik, Universität Siegen, Siegen, Germany
[142]Department of Physics, Simon Fraser University, Burnaby BC, Canada
[143]SLAC National Accelerator Laboratory, Stanford, California, USA
[144a]Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava, Slovak Republic
[144b]Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic
[145a]Department of Physics, University of Johannesburg, Johannesburg, South Africa
[145b]School of Physics, University of the Witwatersrand, Johannesburg, South Africa
[146a]Department of Physics, Stockholm University, Sweden
[146b]The Oskar Klein Center, Stockholm, Sweden
[147]Physics Department, Royal Institute of Technology, Stockholm, Sweden
[148]Department of Physics and Astronomy, Stony Brook University, Stony Brook, New York, USA
[149]Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom
[150]School of Physics, University of Sydney, Sydney, Australia
[151]Institute of Physics, Academia Sinica, Taipei, Taiwan
[152]Department of Physics, Technion: Israel Inst. of Technology, Haifa, Israel
[153]Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel
[154]Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece
[155]International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan
[156]Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan
[157]Department of Physics, Tokyo Institute of Technology, Tokyo, Japan
[158]Department of Physics, University of Toronto, Toronto ON, Canada
[159a]TRIUMF, Vancouver BC, Canada
[159b]Department of Physics and Astronomy, York University, Toronto ON, Canada
[160]Institute of Pure and Applied Sciences, University of Tsukuba, Ibaraki, Japan
[161]Science and Technology Center, Tufts University, Medford, Massachusetts, USA
[162]Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia
[163]Department of Physics and Astronomy, University of California Irvine, Irvine, California, USA
[164a]INFN Gruppo Collegato di Udine, Italy
[164b]ICTP, Trieste, Italy
[164c]Dipartimento di Fisica, Università di Udine, Udine, Italy
[165]Department of Physics, University of Illinois, Urbana, Illinois, USA
[166]Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden
[167]Instituto de Física Corpuscular (IFIC) and Departamento de Física Atómica, Molecular y Nuclear and Departamento de Ingenierá Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain
[168]Department of Physics, University of British Columbia, Vancouver BC, Canada
[169]Department of Physics and Astronomy, University of Victoria, Victoria BC, Canada
[170]Waseda University, Tokyo, Japan
[171]Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel
[172]Department of Physics, University of Wisconsin, Madison, Wisconsin, USA

[173]*Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany*
[174]*Fachbereich C Physik, Bergische Universität Wuppertal, Wuppertal, Germany*
[175]*Department of Physics, Yale University, New Haven Connecticut, USA*
[176]*Yerevan Physics Institute, Yerevan, Armenia*
[177]*Domaine scientifique de la Doua, center de Calcul CNRS/IN2P3, Villeurbanne Cedex, France*

[a]Deceased.
[b]Also at Laboratorio de Instrumentacao e Fisica Experimental de Particulas - LIP, Lisboa, Portugal.
[c]Also at Faculdade de Ciencias and CFNUL, Universidade de Lisboa, Lisboa, Portugal.
[d]Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.
[e]Also at TRIUMF, Vancouver BC, Canada.
[f]Also at Department of Physics, California State University, Fresno CA, USA.
[g]Also at Faculty of Physics and Applied Computer Science, AGH-University of Science and Technology, Krakow, Poland.
[h]Also at Department of Physics, University of Coimbra, Coimbra, Portugal.
[i]Also at Università di Napoli Parthenope, Napoli, Italy.
[j]Also at Institute of Particle Physics (IPP), Canada.
[k]Also at Department of Physics, Middle East Technical University, Ankara, Turkey.
[l]Also at Louisiana Tech University, Ruston LA, USA.
[m]Also at Group of Particle Physics, University of Montreal, Montreal QC, Canada.
[n]Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.
[o]Also at Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany.
[p]Also at Manhattan College, NY, NY, USA.
[q]Also at School of Physics and Engineering, Sun Yat-sen University, Guanzhou, China.
[r]Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.
[s]Also at High Energy Physics Group, Shandong University, Shandong, China.
[t]Also at CA Institute of Technology, Pasadena CA, USA.
[u]Also at Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom.
[v]Also at Section de Physique, Université de Genève, Geneva, Switzerland.
[w]Also at Departamento de Fisica, Universidade de Minho, Braga, Portugal.
[x]Also at Department of Physics and Astronomy, University of South Carolina, Columbia SC, USA.
[y]Also at KFKI Research Institute for Particle and Nuclear Physics, Budapest, Hungary.
[z]Also at Institute of Physics, Jagiellonian University, Krakow, Poland.
[aa]Also at Department of Physics, Oxford University, Oxford, United Kingdom.
[bb]Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.
[cc]Also at Department of Physics, The University of Michigan, Ann Arbor MI, USA.
[dd]Also at DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat a l'Energie Atomique), Gif-sur-Yvette, France.
[ee]Also at Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France.
[ff]Also at Department of Physics, Nanjing University, Jiangsu, China.